Corrosion

Official Publication
NATIONAL ASSOCIATION OF CORROSION ENGINEERS

Vol. 12 APRIL, 1956 No. 4

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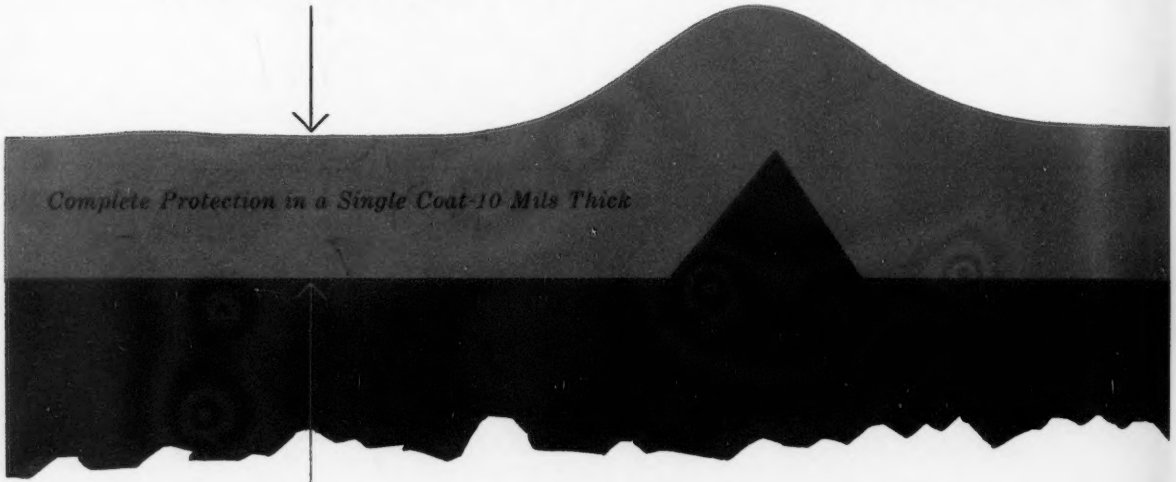

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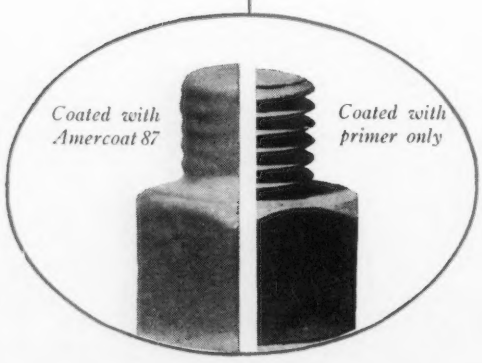

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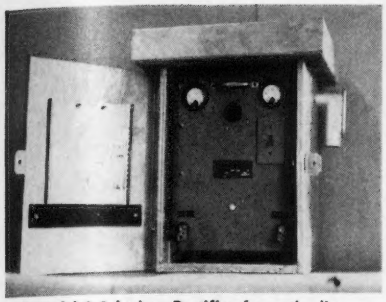

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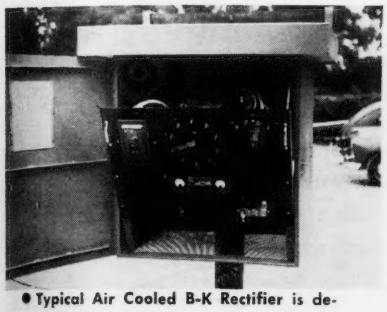

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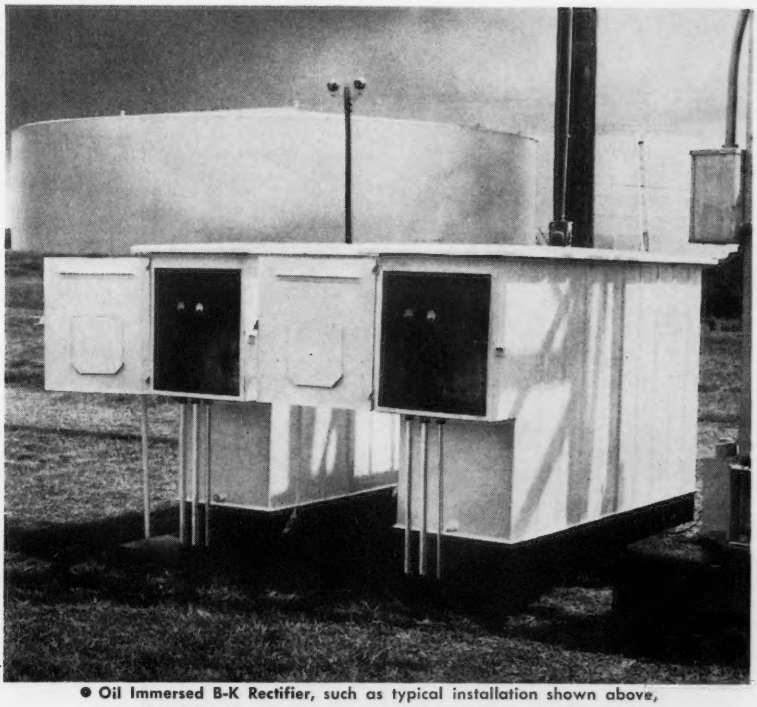

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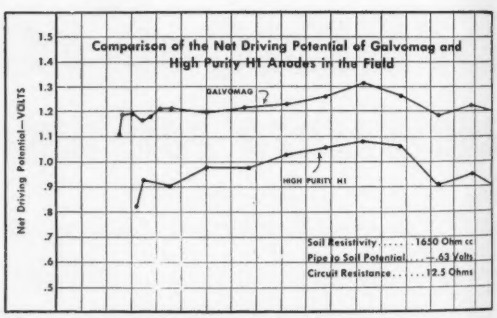

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THIS MONTH'S COVER—This is a view of one of the aisles at the 1956 Corrosion Show held concurrently with the NACE 12th Annual Conference at Hotel Statler, New York City. Ninety-five exhibitors filled 120 booths, making the show the largest held so far by NACE. It was characterized by a wide variety of displays in the major corrosion control fields. Additional scenes from the show are published in this issue.

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John R. Hopkins, Secretary-Treasurer; Protecto Wrap Company, 2249 So. Delaware St., Denver, Colorado

Karl S. Hagius, Trustee; Colorado Interstate Gas Company, Box 1087, Colorado Springs, Colorado

(Continued on Page 8)

R. H. Bohl, prominent painting contractor, states his case for spray painting

"The DeVilbiss spray method benefits everyone — contractors, painters, and customers alike — through better finishes, more jobs, and lower costs . . . "

"We were one of the first companies to use the spray method," relates Richard Bohl, president of the Bohl Painting Company, "and we've watched it grow into the necessity in the industry that it is today.

"You can understand its increasing popularity when you consider its advantages: 100% increase in coverage, lower cost, less scaffolding, less cleaning time needed. What's more, it enables painters to reach areas inaccessible to brush, and opens avenues of business never before available to contractors.

"Spray painting has proved the only answer for many big industrial jobs," he states. "Large buildings with high, vaulted, steel-beamed roofs were seldom painted before the advent of the spray gun. Because of the cost of multiple coats required of brush painting to cover accumulated dirt — plus clean-up time, and the prolonged interference with plant production — painting was beyond consideration.

"Spray painting is not confined to conventional jobs," Mr. Bohl adds. "Many new applications are turning up every day. For example, our recent application of a mastic coating on metal buildings not only served to protect and beautify the exteriors, but increased the insulating value 15%, as well.

"For the past fifteen years," says Mr. Bohl, "we have standardized on DeVilbiss equipment for all our spray jobs. Since equipment downtime can result in failure to meet contract dates, it's important to have good equipment . . . and good service. DeVilbiss spray tools give us unfailing dependability and uniform performance. And we get excellent service from DeVilbiss on parts and maintenance, too."

Improve your business now, by taking advantage of the benefits of the DeVilbiss spray method! Call your supplier for full information on DeVilbiss' complete line of spray guns, hose and connections, paint tanks, compressors, and accessories. Or write us direct.

Richard Bohl, president of the Bohl Painting Company, Columbus, Ohio, and veteran of 35 years in the painting business, has been using the DeVilbiss spray method for more than 15 years.

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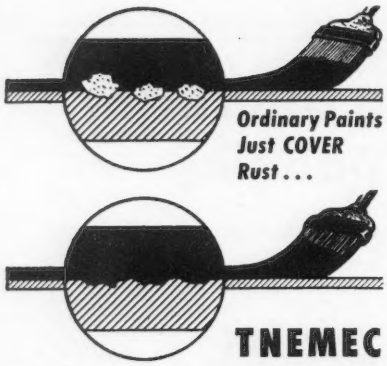

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(Continued from Page 6)

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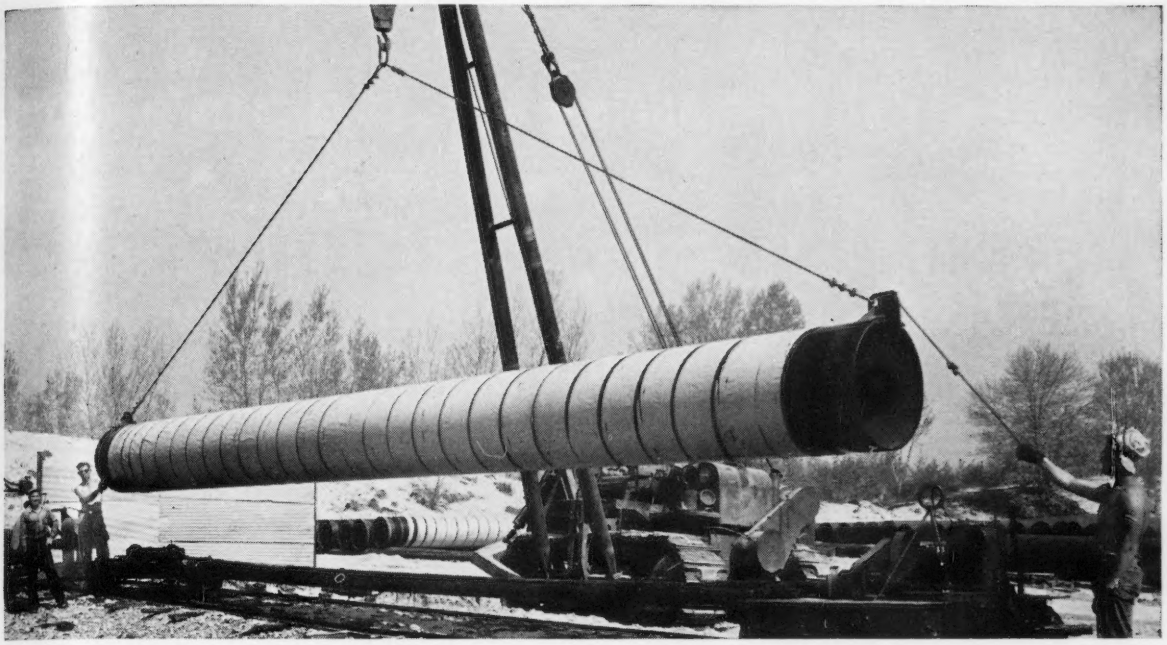
Directories of Regional and Sectional Officers and Technical Committees are run on alternate months. Look for Directory of Technical Committees next in May and Next running of regional and sectional officers in June issue. Early notice of changes will permit keeping these directories up to date.

West Kansas See.

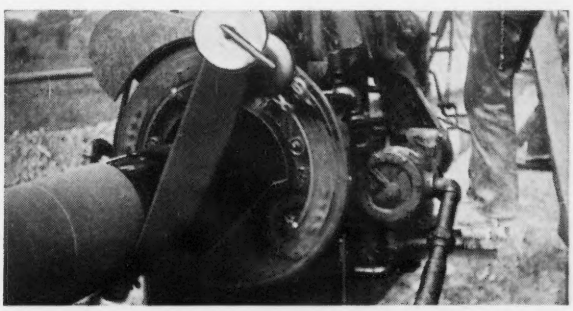
BACK ISSUES OF VOLUME 11

Copies of back issues of Volume 11, January-December, 1955 are available except July. Persons who customarily bind all or parts of Corrosion and who lack issues to make the volume complete may get back copies at the following prices per copy, postpaid, remittance in advance: NACE members, 50 cents; Non-members, $1. An additional charge of 65 cents per package is made for mailings to addresses outside the United States, Canada and Mexico.



KING SIZE PROTECTION: 36″ pipe, mill coated first with NO-OX-ID 6X for bonded insulation against moisture, then shielded with No. 7 NO-OX-IDized Wrapper and Service Coat for added electrical resistance and protection against soil stress. Finally, a kraft wrap to protect from damage in handling operations. This is long-term pipeline protection at its best.

WHERE ELBOW ROOM IS SCARCE: In crowded work space, No. 4 NO-OX-IDized Reinforced Fabric Wrapper is hand applied around irregular fittings such as valve manifolds on gas lines. No. 4 Wrapper, a coated fabric laminated to a plastic membrane, provides moisture-proof seal over pipe coating.



PROTECTION BY THE MILE: A NO-OX-ID coating combination is uniformly applied over-the-ditch by this traveling type machine. The NO-OX-ID 6X Base Coating is covered with an unbroken shield of No. 7 NO-OX-IDized Wrapper. The fabric side of the wrapper is an excellent surface for bonding a service coat.

NO-OX-ID PROTECTS...EVERYWHERE

Wherever pipelines go—into long or short line service, through rough terrain or rolling plains—there is a NO-OX-ID coating combination plus a method of application for long-term protection against corrosion.

WRITE FOR BULLETIN "Protecting Underground Pipe from Corrosion with NO-OX-ID and NO-OX-IDized Wrappers" tells the story. Your copy is ready upon request.

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Gentlemen:
Please send my copy of "Protecting Underground Pipe from Corrosion with NO-OX-ID and NO-OX-IDized Wrappers."

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Company.....

City.....*Zone*....*State*.....

Dearborn NO-OX-ID®

Protecting Metal Against Corrosion Since 1887

do you want low-cost corrosion or contamination

Acetone • Borax • Calcium Carbide • Calcium Carbonate • Calcium Chloride (Flake) • Ethyl Acetate • Ethyl Alcohol • Ethylene Glycol • Glycerine • Insecticide Concentrates • Soap and Soap Lye • Soda Ash • Sodium Bicarbonate • Sodium Silicate •

CF&I

LECTRO-CLAD® Nickel Plated Steel Plates will give it to you

Yes, you can get low-cost, yet effective protection against contamination and corrosion with all these chemicals...and many more!

Effective in heavy industrial applications where the corrosion rate does not exceed 0.0015 inches per year, CF&I LECTRO-CLAD Nickel Plated Steel Plates successfully combine the corrosion and contamination resistance of nickel and the economy and strength of carbon steel.

That's because CF&I LECTRO-CLAD is made by the Bart Process, which consists of electrodepositing a heavy layer of 99% pure nickel on a carbon steel plate. This process results in a permanent bond between the nickel and the steel base. The nickel plating is customarily supplied in the 8-10 mil range; however, it can be plated up to 15-20 mils, if specified.

What's more, CF&I LECTRO-CLAD Nickel Plated Steel Plates are easily fabricated without costly special equipment. Just use regular shop equipment and bend it... weld it... roll it—the protective nickel layer will not check, spall or flake!

Ask our nearest sales office for the complete story on economical, effective, easy-to-fabricate CF&I LECTRO-CLAD Nickel Plated Steel Plate* today. Wickwire Spencer Steel Division, The Colorado Fuel and Iron Corporation, P. O. Box 1951, Wilmington, Delaware.

***CF&I LECTRO-CLAD Nickel Plated Steel Sheets, Pipe, Fittings and Heads are also available.**

protection against with these chemicals?

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Methyl Alcohol • Petroleum Catalysts • Phenol • Potash • Resin Plasticizers • Salt
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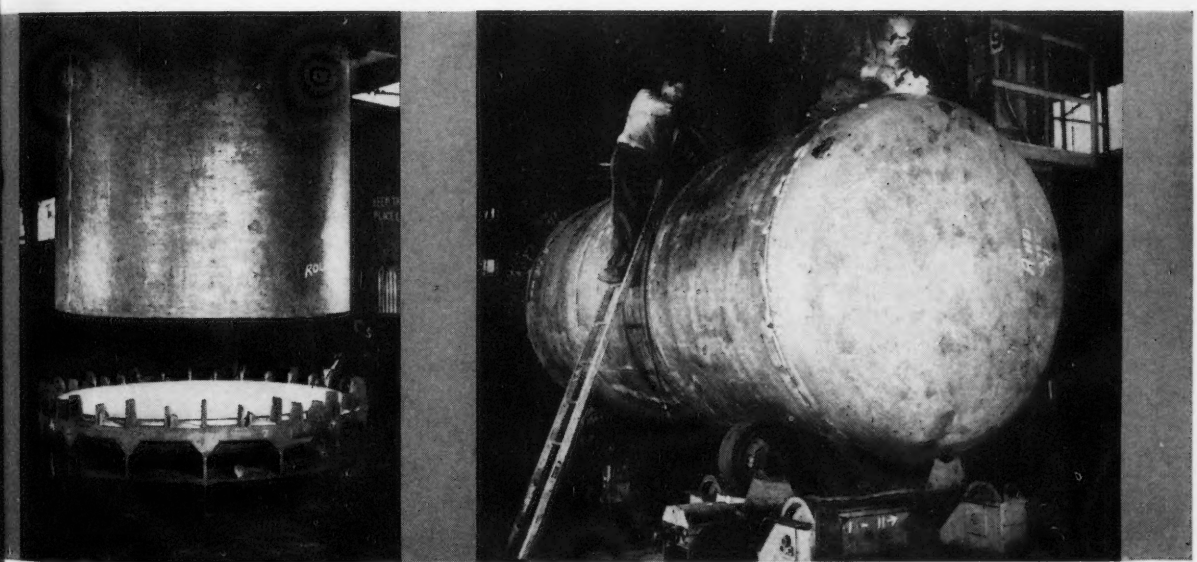

Assembling a tank fabricated from CF&I LECTRO-CLAD Nickel Plated Steel Plates.
The heads have also been nickel electroplated by the Bart Process.

3798

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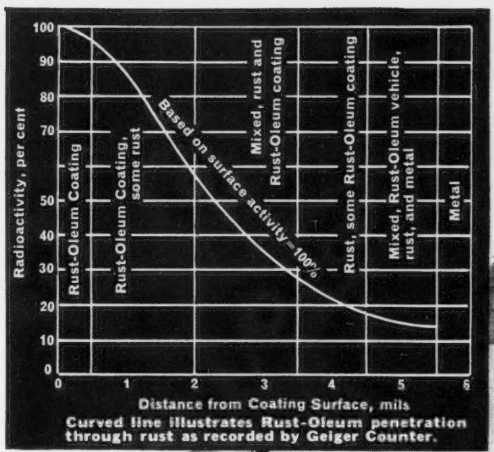
PENETRATION

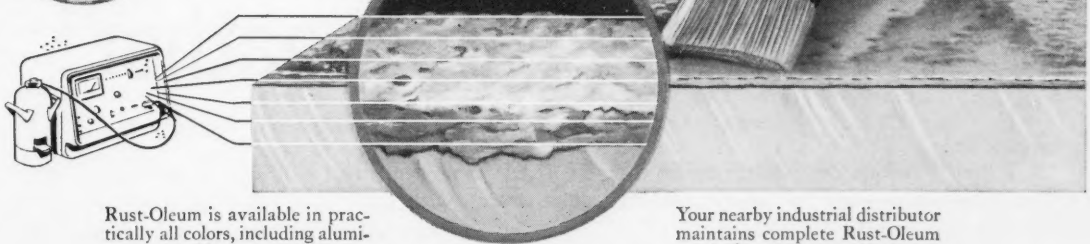
through rust to bare metal traced by Geiger Counter. To effectively stop rust—the vehicle of a protective coating, when applied over a sound, rusted surface—must penetrate through the rust down to bare metal. **Rust-Oleum does exactly that!—as proved by radioactive research!** Rust-Oleum's specially-processed fish oil vehicle was radio-activated and formulated into Rust-Oleum 769 Damp-Proof Red Primer—then applied to rusted test panels. Penetration *through rust* to bare metal by Rust-Oleum's specially-processed fish oil vehicle was then traced by Geiger Counter.

You stop rust, because Rust-Oleum's fish oil vehicle soaks deep down to bare metal and into the tiny pits where it drives out air and moisture that cause rust. You save, because this same *penetration* enables you to apply Rust-Oleum directly over rusted surfaces—usually eliminating costly surface preparations. Attach coupon to your letterhead for your thirty-page report entitled, "The Development of a Method To Determine The Degree of Penetration of a Rust-Oleum Fish-Oil-Based Coating Into Rust On Steel Specimens," prepared by Battelle Memorial Institute technologists.



Curved line illustrates Rust-Oleum penetration through rust as recorded by Geiger Counter.

There is only one Rust-Oleum. It is distinctive as your own fingerprint. Accept no substitute. Buy—and specify only Rust-Oleum. You'll be happy that you did.



Rust-Oleum is available in practically all colors, including aluminum and white.

Your nearby industrial distributor maintains complete Rust-Oleum stocks for your convenience.

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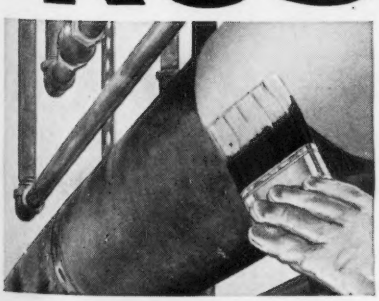

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"SCOTCHRAP" rolls on easy ...even in zero weather!

"Scotchrap" conforms smoothly, handles easily at high or low temperature — and the pressure-sensitive adhesive sticks tight, too — even at 0°-10°F!

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"Scotchrap" is a tough vinyl plastic tape that resists abrasion above or below ground, resists galvanic and electrolytic action, resists damage from oil, water, acids, alkalies, weathering and sunlight. *Make sure you get the tape with the green adhesive.*

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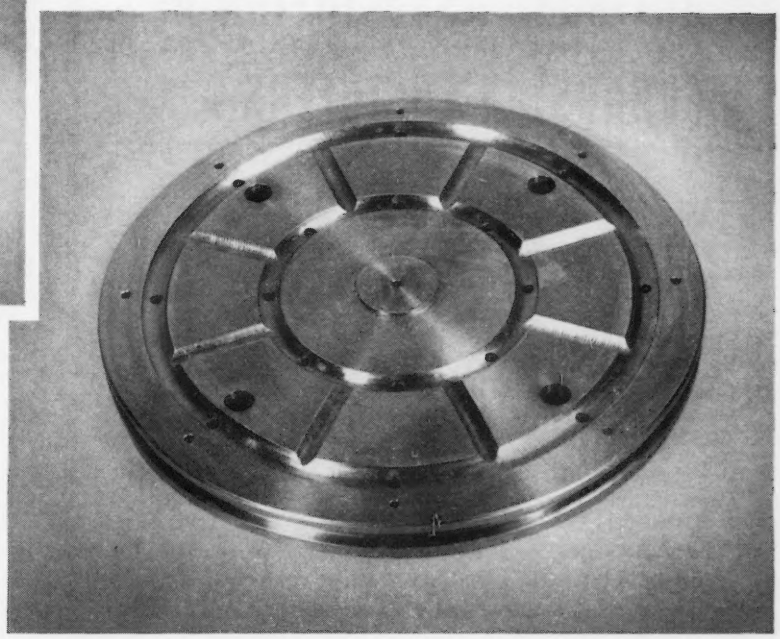
CORROSION-RESISTANT COMPONENT of filter press unit is severely pitted from chloride ion attack of calcium hypochlorite in just 2 weeks.



TITANIUM COMPONENT of filter press is clean, uncorroded after 7 months' exposure to calcium hypochlorite solution.

Titanium Filter Press Resists Attack of Corrosive Bleach

Pennsalt titanium unit shows no sign of chloride pitting after seven months' use

At Pennsylvania Salt Manufacturing Co., titanium is used for contact parts of the filter press employed in making solid cakes of calcium hypochlorite from corrosive slurries for hypochlorite bleach. Here the problem was to find a construction material for the unit able to withstand the highly corrosive effects of strong hypochlorite solutions. Corrosion-resistant components, ordinarily used, developed severe pitting corrosion from chloride ion attack in a matter of weeks.

After testing many metals, titanium was selected and adapted to equipment used in the most critical operations. The titanium unit at Pennsalt has been in operation for seven months and it still shows no sign of corrosion. Tool markings left by machining operations are still clearly visible on titanium parts.

Titanium again solves a corrosion problem by extending the life of essential equipment. If severe corrosion is *your* problem, titanium may be the answer.

DU PONT CAN HELP YOU START YOUR EVALUATION TESTS NOW

As a pioneer in the commercial production of titanium sponge and development of industrial applications of titanium, Du Pont can offer you expert technical help. And Du Pont can put you in touch with manufacturers best equipped to work along with you. Considerable fabricating know-how and a wide variety of mill shapes are *now* available to help solve your corrosion problems. For more detailed information on titanium, just check coupon below.

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TITANIUM SPONGE

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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

(a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.

(b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.

(c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.

(d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.

(e) To promote standardization of terminology, techniques, equipment and design in corrosion control.

(f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.

(g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.

(h) To invite a wide diversity of memberships, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 1061 M & M Building, No. 1 Main Street, Houston 2, Texas.

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Corrosion

OFFICIAL MONTHLY PUBLICATION

National Association of Corrosion Engineers

An Association of Individuals and Organizations Concerned with Control of Corrosion

1061 M & M Building Houston 2, Texas

Vol. 12 April, 1956 No. 4

Topic of the Month

Railroad Motive Power—and Corrosion

By S. K. COBURN*

DURING THE past 15 years there has taken place one of the greatest revolutions in the history of motive power. Some 22,500 diesel-electric locomotives have replaced approximately 65,000 steam engines.

In 1940 one-twentieth of one percent of all freight service (comprising about 90 percent of railroad income) was handled by diesel power. Today 85 percent of all freight and passenger service is diesel-driven. Ninety-eight percent of the diesels in use today were built during the past 15 years, with half of them no more than five years old. The savings effected in fuel costs alone aggregate over a half-billion dollars annually. No other technological development has contributed to the financial stabilization of the nation's railroads as has the utilization of diesel power.

When dieselization is completed at an estimated 30,000 units, approximately 3.75 percent of the crude oil barrel will be required for fuel and lubrication purposes. Because of shifting requirements and future availability of various fuel oil components, as well as mechanical advantages, one railroad has pioneered in the use of the residual oil-burning gas turbine-electric locomotive. It has obtained satisfactory performance with 25 such units and within another two years will have a fleet of 70 in service. Paralleling the mechanical engineering development of these two new forms of motive power are a series of corrosion problems peculiar to their respective operations.

Diesel Fuel and Lube Oils

A diesel locomotive, properly operated and maintained, can log as much as 750,000 miles before requiring extensive overhauling. During this period the lubricating and fuel oil needs total almost 70 percent of the original cost of the engine. Because of this ratio several railroads have directed their attention to the possible use of lower cost residual oil fuels. These oils, being residues in a sense, contain in concentrated form elements present in crude oil accompanied by active polymerizing systems, both of which are conducive to corrosion. Premium fuels contain sulfur up to a maximum of 0.5 percent. Where higher sulfur concentrations are encountered sulfur acids become a combustion product capable of corroding liners, rings, valves and pistons. Where copper fuel lines and sintered bronze filters are in use, copper corrosion develops as a result of the presence of free sulfur and complex polysulfides.

Bearing failures develop when lubricating oils are aggressive toward copper-lead babbitts leaving lead depleted areas. Bearing corrosion has been overcome to some degree by incorporating tin and antimony and achieving results similar to those obtained when nickel and chromium respectively are alloyed with steel. A measure of the corrosive tendency of both fuel and lubricating oils can be obtained by immersing a copper strip in the oils maintained at elevated temperatures.

Incorporation in fuel oil of dibutyl sulfide containing radioactive sulfur, and its subsequent identification in the crankcase oil ash throws some light on the mechanism by which corrosion takes place. Similar studies utilizing a piston ring which has been made radioactive by exposure in an atomic reactor and then placed in service in a diesel engine have been carried out. Periodic analysis of the crankcase oil indicates both the efficiency of the lubricating oil and the point of incipient corrosion. A number of railroads now are using spectrographs as a control instrument to detect excessive concentrations of metals in the crankcase sediment.The presence of such excessive concentrations might indicate lack of thorough lubrication, lube oil breakdown, water cooling system leaks and piston or liner wear. Such information affords an opportunity of withdrawing the engine from service and investigating conditions before any extensive damage can develop, such as crankshaft scoring or injector corrosion.

The jewel of the diesel engine is the fuel oil injector assembly. The parts are produced and assembled in

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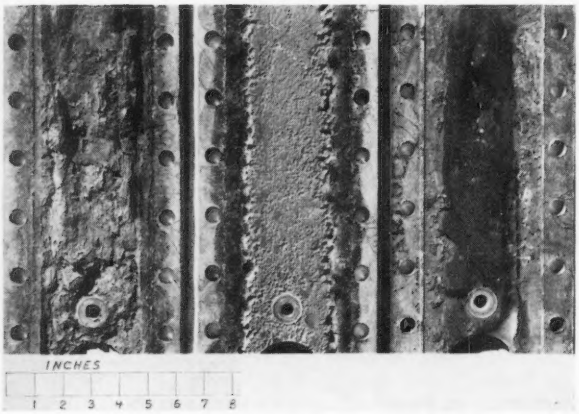

Figure 1—Left to right: examples of corrosion caused by high pH, galvanic coupling, and erosion on aluminum header in cooling system.

air-conditioned, dust-free rooms in such a fashion as to minimize any possibility of surface corrosion. It is necessary to do this because tolerances on the injector plunger and bushing are of the order of 0.00005 inch.

Where economies must be effected, and the future availability considered, the judicious use of lower cost fuel oils becomes a matter of serious concern. Intensive work by one railroad indicated a 50 percent reduction in both fuel cost and corrosion upon using one quart of a proprietary additive, containing a corrosion inhibitor, to 1,000 gallons of a shale oil derivative. The important effect achieved was to reduce and maintain colloidal particle size to no more than 0.1-0.25 microns in diameter.

Diesel Cooling System

The diesel cooling system supplies an ideal closed circuit for the creation of a variety of corrosion phenomena. These can take the form of cavitation erosion, crevice corrosion and corrosion due to galvanic couples. They result from unavoidable factors in design requiring the use of such materials as brass, bronze, a variety of solders, stainless steel, cast iron, copper, aluminum, synthetic rubbers derived from silicones and neoprene for use in hoses, gaskets, and seals. The use of cooling system inhibitors is almost universal. The formulation, however, of effective inhibitors becomes especially difficult with such combinations of materials. In addition to this the inhibitor must be compatible with anti-freeze materials, must be non-foaming, non-sludging, harmless when mixed accidentally with lube oil, unaffected by salt, stable in storage and at a variety of temperatures, economical, and non-hazardous to personnel.

Constant improvement in design as well as in inhibitor formulation have brought under control much of the cooling water corrosion. Three common forms of corrosion are illustrated in Figure 1. An abuse of the old adage that "if some is good more is better" is shown on the left, where severe exfoliation of an aluminum header has occurred due to application of twice the recommended concentration of an alkaline inhibitor. The center panel illustrates a similar aluminum header suffering pitting corrosion as a result of galvanic action because of contact with a brass radiator and plate. The right panel is an example of erosion demonstrating a velocity effect.

Gas Turbine Fuels

A gas turbine-electric power plant is similar to a jet engine except that there is no jet "thrust" to the atmosphere. Connection is made to generators which supply power to wheel-driving motors. A low cost Bunker C fuel oil containing a variety of ash formers such as vanadium, sulfur and sodium is the principal fuel. Corrosion of turbine components is aggravated by the formation of sodium sulfate, a bulky ash producer, and vanadium pentoxide, which seriously affects many alloy systems. Vanadium forms high melting tri and tetroxides; however, eventual formation of the pentoxide results in a compound melting at 1200 F in a system whose temperatures range up to 1600 F. This is unfortunate because the vapor pressure of the pentoxide is such that volatilization takes place with subsequent condensation in areas susceptible to damage.

What is called "catastrophic" corrosion occurs by vanadium pentoxide in the range 1200-1300 F and by sodium sulfate between 1600 and 1700 F. Corrosion occurs only in the liquid phase of the ash; thus, attempts to inhibit corrosion by means of additives requires the formation of compounds of higher fusion points and lower vapor pressures. Corrosive conditions can be minimized by specifying a vanadium to sodium ratio and a vanadium to calcium ratio. Such a fuel at present commands a premium price.

Integration of Corrosion Control In Pier Substructures*

By CARL R. JOHNSON

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Abstract

Integration of cathodic protection in design of three piers in New York Harbor is described. All are constructed of steel H-piling driven to rock. Rectifiers were selected in lieu of galvanic anodes and a provision was made to locate controls for all circuits in an alarm panel. When any circuit drops below 50 amperes, the circuit light goes out and an alarm bell rings. Details of installation, criteria of protection and other details of tests, surveys and installation are given. Test or control piles have been driven to make possible a check on the effectiveness of the protection.

Introduction

THE PORT of New York Authority has completed the construction of two new piers during the past year. These structures are the Waterman Wharf at Port Newark and Pier C at Hoboken, New Jersey. A third, Pier A, is now under construction at Hoboken.

The substructures of all three piers are similar to the extent that they consist of steel H-piling driven to rock. Protection of this steel against corrosion was considered in the original design, particularly so after a study was made of the effects of corrosion of unprotected steel piling in local waters. A specific study at one location in the Hudson River showed a maximum weight loss of 35 percent in a 14-inch—89-pound steel pile in certain sections near mean low water after seven years exposure (Figure 1)

A decision was made to proceed with cathodic protection, integrating these requirements with the over-all design of each structure. A consulting firm was engaged to design the cathodic protection features, working with the Port Authority on the design of the Waterman Terminal and with Parsons, Brinkerhoff, Hall, and Macdonald on the design of the Hoboken Piers. Excellent means were thus provided in the design stages for flexibility of control, periodic testing, accessibility, and ease of maintenance. The adoption of rectifiers in lieu of galvanic anodes was made on the basis of cost and flexibility for the particular applications.

Fundamentals

Cathodic protection, by definition, is the use of an applied current to prevent or retard corrosion of a metal surface. For the subject installations, its function was to prevent corrosion (loss of iron) on the "H" and sheet piling in the water zone and below the mudline.

The protective system consists of four elements: Anodes (source of protective current), cathode (pile surfaces receiving the protective current), rectifier (source of impressed potential to drive protective current), and the electrolyte (corrosive sea water and silt through which the protective current flows).

The components of a typical cathodic protection system are shown in the general wiring diagram and details for Pier A (Figures 2, 3, 4).

Protective current from the positive (+) terminal of the rectifier is applied to the anodes. The current flows through the water to the submerged pile surfaces whereon the protective effect is achieved. The piles in each bent are bonded electrically by a metallic conductor (reinforcing bars) to the building structure and the collected current is returned to the negative (—) terminal of the rectifier.

A rectifier alarm system is used to indicate proper functioning of the protective system. Normally, all lights on the alarm panel in the control room are lighted. Should the DC output of a rectifier drop below 50 amperes, the light on the panel corresponding to this rectifier darkens and the alarm bell rings.

Complete protection of steel in sea water is attained when the structure has been polarized to a potential of —.78 volts or more electro-negative measured against a saturated KCl calomel reference electrode. Measurement of —.80 volts against a Ag-AgCl sea water reference electrode is the protective potential at this location (Hoboken). A $CuCuSO_4$ reference electrode for continuous use under sea water is not recommended because chloride iron contamination will alter its potential.

Waterman Terminal

The 1650 foot wharf apron for the Waterman Terminal is supported by 232 bents (parallel rows of piles), each bent consisting of four vertical piles and one diagonally driven batter pile. Before driving, the surfaces of these piles which were to remain

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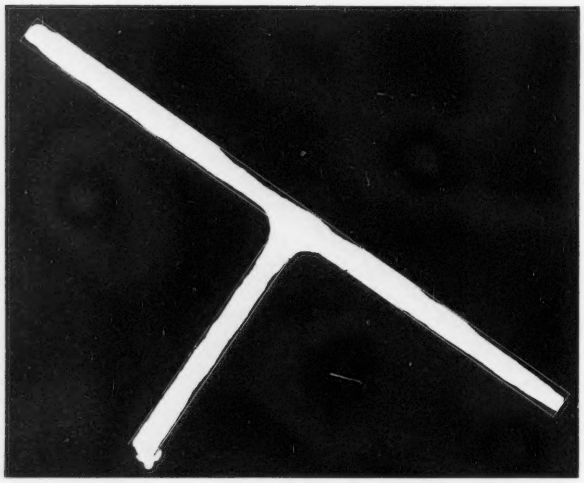

Figure 1—Section of unprotected steel H piling after seven years exposure.

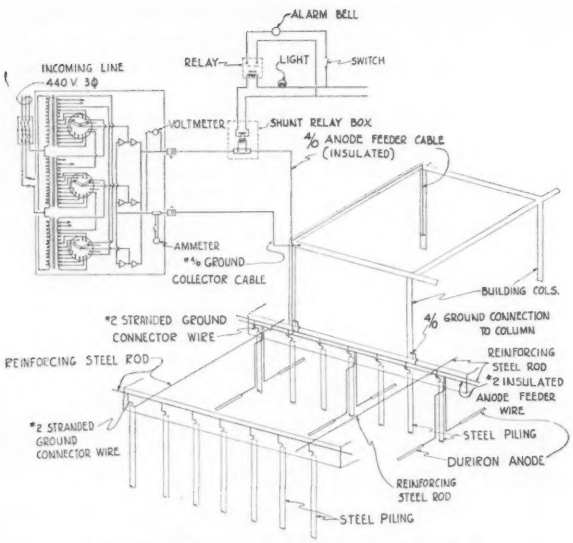

Figure 2—General wiring diagram for Pier A.

above the mud line were cleaned and coated with a coal tar application.

Access handholes were constructed between each bent and 4-inch × 80-inch "NA" graphite anodes supported by Saran rope placed on the rip-rap below each handhole.

All piles were bonded electrically by means of lap-welded reinforcing bars at each bent and two No. 8 insulated wires brazed to the bars were brought separately to each handhole. One of these wires was connected to the common collector cable return to the negative (—) terminals of the rectifiers. The other wire was attached to an eye in the handhole for testing purposes. All anodes were connected to a common feeder cable supplied by the rectifiers (Positive terminals).

The capacity of the DC system was premised on 5 milliamperes per square foot of steel surface in the water zone and 1 milliampere per square foot of steel

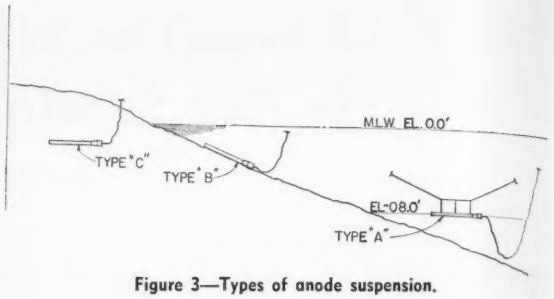

Figure 3—Types of anode suspension.

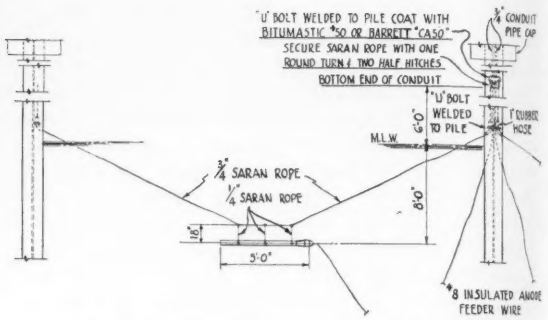
"U" BOLT WELDED TO PILE COAT WITH BITUMASTIC #50 OR BARRETT "CA50"
SECURE SARAN ROPE WITH ONE ROUND TURN & TWO HALF HITCHES
BOTTOM END OF CONDUIT
¾" CONDUIT PIPE CAP
"U" BOLT WELDED TO PILE
RUBBER HOSE
M.L.W.
6'0"
¾" SARAN ROPE
½" SARAN ROPE
80'
5'-0"
#8 INSULATED ANODE FEEDER WIRE

Figure 4—Suspension diagram—Type "A" anode.

surface in the mud zone. Seven rectifiers operating in parallel, each rated 200 amperes, 10 volts (1 at 20 volts) were installed to fulfill the requirements. At each rectifier, a shunt relay was provided to give visual and audible supervision at a central station.

Four test piles with recorded flange and web dimensions were driven at the Southeast corner of the wharf as follows:

1. Test pile had neither coating nor cathodic protection.
2. Test pile had a CA 50 coal tar application to the mudline but was without cathodic protection.
3. Test pile had no coating but had cathodic protection.
4. Test pile had both coating and cathodic protection.

Current drained from two test piles and potential profiles of all four piles are being checked periodically. Present plans are to pull these piles in 1957 (after three years) for further measurements. They will be replaced under control conditions and re-examined in 1960.

Hoboken, Pier C

Hoboken Pier C, with an overall length of 700 feet from the bulkhead line and a width of 328 feet, is supported by 1440, 14-inch—89-pound steel H piles driven to rock. All piles are connected to the building superstructure through a grid of copper wire connections brazed to reinforcing bars. The sheet piling of the cofferdam at this pier is similarly bonded to the superstructure.

Two hundred and twenty 6-inch x 80-inch "NA"

Type graphite anodes were installed in accordance with one of three methods shown in Figure 3. Type "A" anode support was used to support the graphite below the water (to minimize ice and floating debris damage) and above the silt to obtain longer anode service.

Type "B" anode was used in areas where firm fill existed between mean low water (MLW) and minus eight feet below MLW.

Type "C" anode, with coke breeze backfill, was used in areas where the grade was above MLW. The purpose of the coke breeze backfill is to prevent anode gas blockage and to increase the service life of the anode.

When the same design criteria was used, as for Waterman Pier, eleven 200 ampere rectifiers were required to provide adequate protective potentials. Other components of the system are similar to those previously described.

In addition to two test piles being driven at the site, four Ag-AgCl reference electrodes (in equilibrium with the chloride ion in the sea water at the Hoboken location) and two hot rolled steel plates (¼-inch x ¾-inch x 3-inch) were placed below the mudline. This was done to help establish the nature of the corrosion system on the piling and to demonstrate the response of the piling to cathodic protection. The Ag-AgCl reference electrodes were calibrated against a saturated KCl calomel reference electrode. The reference electrodes were furnished by the Electro Rust-Proofing Corporation and installed in accordance with their recommendations.

There are two corrosion systems occurring on the "H" piling of Pier C and the effects of these systems are superimposed on one another.

Corrosion System 1

In the water zone, there are corrosion cells established between areas of differential aeration. For example the area just below MLW is anodic (corrodes) when coupled to the area just being submerged (aerated) in the rising tide. This form of corrosion is most intense because of the short lines of corrosion current flow and the low resistivity of the sea water.

Corrosion System 2

A corrosion cell was found to exist on the piling between the unaerated zone below the mudline (anodic) and the zone in aerated water (cathodic). The intensity of corrosion below the mudline will be less than in System 1, because the flow lines of corrosion current are longer and the resistivity below the mudline is higher.

Test Location A. Two silver-silver chloride reference electrodes were located through an opening in the Pier deck in mud near Column Row "C" and between pile rows 13 and 14 (See Figure 5). Reference electrode "b" was positioned 36 feet below MLW (20 feet below mudline) and electrode "c" was positioned 94 feet below MLW (78 feet below mudline). The reference electrodes were positioned alongside of the piles by driving a two-inch diameter casing through the mud-silt to bedrock. The inside of the driven casing was washed out by a hose lowered to bedrock. The reference electrodes were lowered to the desired elevation and the casing retracted over the insulated lead wires.

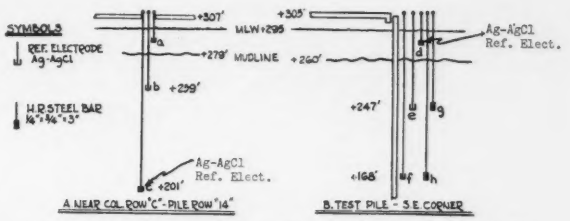

Figure 5—Diagram showing reference electrodes for Pier C.

A potential gradient was noted indicating corrosion current flow from location "c" to "b" and "a" respectively (see Table 1). Electrode "a" is located in water below MLW.

After cathodic protection was applied, this potential gradient was overcome and a pile potential more electro-negative than —.80 volts was measured against an Ag-AgCl reference electrode at locations "a" and "b," and this potential value was approached at "c." Failure of the reference electrodes occurred during the studies (after February 18, 1955.) It is possible this failure could have occurred because of damage to the wire insulation caused by stress of the iron weight attached to a loop in the lead wire two feet below the reference electrode. The effect of the flow of protective current to the piles at locations "a," "b" and "c" was demonstrated by the measurement of change in the potential gradient toward the pile when 1700 amperes of protective current to Pier C was applied.

Test Location B. Two silver-silver chloride and the two HR steel electrodes were located beside the test pile coupled to the Pier structure, at the southeast corner of Pier C (see right side of Figure 5).

Electrodes "g" and "e" were positioned 48 feet below MLW (13 feet below mudline) and "f" and "h" 127 feet below MLW (92 feet below mudline) respectively.

TABLE 1—Field Corrosion Test Data Summary (Pier C Pile Potentials)

Potential Measured	Pile Protective Potential[1] with Various Currents					
	Ip = 0	Ip = 0	Ip = 1900	Ip = 1700	Ip = 0	△E (On-Off)
Pile to a	—645MV[2]	—670MV[3]	—1150MV[5]	—1050MV[6]	—900MV[6]	—150MV[6]
Pile to b	—665MV[2]	—665MV[3]	— 870MV[5]	— 380MV[4,6]	—360MV[4,6]	— 20MV[6]
Pile to c	—740MV[2]	—730MV[3]	— 770MV[5]	— 580MV[4,6]	—550MV[4,6]	— 30MV[6]
g to d	.....	—715MV[3]	.....	.....	.....	.....
h to d	.....	—765MV[3]	.....	.....	.....	.....
Pile to d	.....	—645MV[3]	— 860MV[5]	— 965MV[6]	—950MV[6]	— 15MV[6]
Pile to e	.....	+190MV[3,4]	+ 35MV[4,5]	.....	.....	.....
Pile to f	.....	+175MV[3,4]	— 105MV[4,5]	.....	.....	.....
Pile to g	.....	+ 75MV[3]	— 7MV[5]	— 6MV[6]	— 6MV[6]	0MV[6]
Pile to h	.....	+105MV[3]	— 26MV[5]	— 90MV[6]	— 90MV[6]	0MV[6]

[1] 800 MV versus Ag-Ag Cl reference electrode.
[2] Inspection date was Jan. 4, 1955.
[3] Inspection date was Feb. 2, 1955.
[4] Insulation leakage affected Ag-Ag Cl reference electrode. Insulation was damaged by attached weight at bottom.
[5] Inspection date was Feb. 18, 1955.
[6] Inspection date was Mar. 30, 1955.
Note: Protective Current Ip was 1700 to 1900 amps.

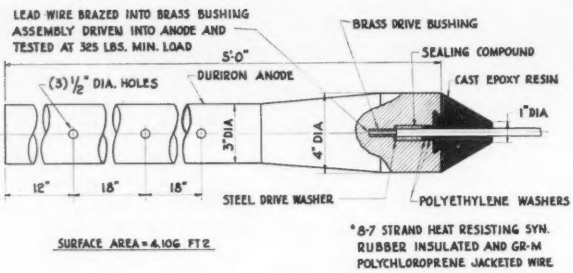

Figure 6—Cable assembly of Duriron anode—Pier A

The potential of the steel electrodes "g" and "h" and of the pile to the Ag-AgCl reference electrode "d" (in water) indicate a corrosion current potential gradient through the mud and silt from the foot of the pile to the water zone. This indicates that some corrosion will occur below the mudline on an unprotected pile.

After the application of cathodic protection, the pile was made more negative in potential to all reference electrodes "d," "e," "f," "g" and "h." This indicates a net current flow into all zones of the piles and assures corrosion protection. The pile has been made negative to the independent steel electrodes "g" and "h."

The absolute pile potential values measured to reference electrodes "e" and "f" were not determined. These electrodes appeared to have been damaged during or shortly after positioning below the mudline.

Direct measurement of pile to Ag-AgCl reference electrode potentials and the interpretation of pile to steel reference electrode potentials indicated that effective corrosion control was being achieved over the full length of the pile.

The final evaluation of the effectiveness of cathodic protection in controlling corrosion will be made in January 1960, by comparing the section losses of the (a) unprotected test pile on the south side of Pier 3 and (b) the cathodically protected test pile on the southeast corner of Pier C.

Hoboken—Pier A

Hoboken Pier A which is scheduled for completion soon is almost a duplicate of Pier C. With regard to cathodic protection of the substructure, however, there is one distinct difference. The anodes specified are of "Duriron" with a new design of lead assembly (Figure 6).

Taped lead end connections to the "NA" graphite anodes which were employed on the previous two installations proved somewhat difficult to make water-tight and involved considerable field labor to apply.

The new 14.5 percent silicon iron anodes are less costly and are completely fabricated at the factory, including holes for rope supports and wire leads of length to suit job conditions. The design of the lead assembly provides adequacy of mechanical strength, a true moisture seal, and permanence of the electrical connection. Less breakage due to floating objects is anticipated and somewhat longer life of the anodes is expected.

Conclusions

Tests completed to date indicate that adequate pile potentials are being maintained both in winter and in summer and that the steel in both the water and the mud zones is fully protected against corrosion.

Interference tests made after cathodic protection was applied showed negligible or no change of potential on nearby substructures and underground utility lead cables.

The number of test or control piles driven will assure an accurate appraisal of the effectiveness of cathodic protection in the years ahead.

Any discussions of this article not published above will appear in the June, 1956 issue

Corrosion Investigations Related to Adsorption Studies*

By C. C. NATHAN

Abstract

Investigations have been conducted on a variety of amines and organic acids, in attempts to correlate the structure of the molecules with their adsorption characteristics from benzene solutions at room temperature. Correlations were made also between molecular structure and the effectiveness of the film adsorbed on iron powder as an inhibitor to attack on the powder by aqueous acetic acid.

Adsorption and desorption data were quantitatively evaluated where possible. It was found that strongly adsorbed materials generally gave more protection to the coated powders than did weakly adsorbed, easily desorbed materials. Adsorption in a homologous series was found to increase, in general, as the solubility of the homolog decreased, in accordance with Traube's rule of adsorption. A secondary amine seems to be much less effective as an inhibitor than a primary amine having the same number of carbon atoms. Tertiary amines were adsorbed to a smaller degree than either primary or secondary amines.

Branching of the alkyl chain of aliphatic amines decreases the ease of adsorption from solution. Aromatic amines which contained more than one aryl group attached to the nitrogen were found to be adsorbed only weakly and to be poor corrosion inhibitors. The presence of multiple polar groups did not result in substantially greater adsorption as shown by adsorption isotherm data.

Correlations between inhibition by aromatic acids and adsorption from alcoholic solutions were poor. None of the adsorbed acids functioned as inhibitors.

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Introduction

INVESTIGATIONS have been conducted for some time on the nature of the so-called organic film forming inhibitors. It was thought that information on the adsorption characteristics of these inhibitors might yield data which could be correlated with their value as corrosion inhibitors. A systematic study of various compounds was initiated to determine, if possible, what characteristics or properties of the inhibitor molecule were of importance in contributing to the value of that molecule as an inhibitor.

Two approaches were employed. One was the investigation of water or acid soluble inhibitors by dissolving the inhibitors in acid, and then measuring the rate of attack of the inhibited solution on both finely divided iron powder and steel strips. Inhibitor efficiencies were calculated by comparing these rates with those for the uninhibited acid under similar conditions. The method of carrying out the experiments, treatment of the data, and conclusions gathered therefrom have been described previously.[1] All of the materials mentioned in the paper cited were amines.

The present paper is concerned with materials which are essentially insoluble in water and dilute acid, but which are soluble in organic solvents such as benzene. These are the so-called "oil soluble" inhibitors. The approach to the study of these materials was to adsorb them on iron powder from their solutions, dry the powders of excess solvent, and then measure the rate of attack of acid on the powders by the hydrogen evolution method (see reports by Hackerman and Cook[2,3,4]). The rate of attack under similar conditions was determined for the acid on untreated powder, and the inhibition efficiency calculated as the reduction in the rate of the treated as compared to the untreated powder.

Theoretical Considerations

Hackerman and Cook carried out studies of this type on a number of high molecular weight fatty acids, alcohols, amines, and esters. They determined the adsorption isotherms of these materials from their benzene solutions at 25 C onto mild steel powders. These powders subsequently were freed of excess solution, dried and contacted with 3N hydrochloric acid. They measured the time (t) necessary for evolution of fixed quantities of hydrogen and compared the times with that observed (t_o) during action of the acid on the untreated steel powder. The percentage inhibition of the treated powder is 100 $(t-t_o)/t_o$.

In this work benzene was employed as a solvent in most cases; a few aromatic acids were investigated in methanol because of their insolubility in benzene. It was found that in most cases hydrochloric acid attacked the inhibited powders as fast as the uninhibited powders. This was not true, however, of acetic acid. For this reason 1N acetic acid was employed as the standard acid in these experiments.

In general, the plot of volume of hydrogen evolved with time is not linear, nor can it be expressed by a simple mathematical function. It is, therefore, necessary to select either an arbitrary time or volume for comparative purposes. The time at which an un-

* Submitted for publication July 5, 1955. A paper presented at a meeting of the South Central Region, National Association of Corrosion Engineers, Houston, Texas, October 18-21, 1955.

treated sample of iron powder weighing one gram gives 100 cc of hydrogen in normal acetic acid was selected. The volume, V, which is evolved by the acid on treated powder during the same time is then measured, and the percentage inhibition is defined as 100 — V.

Hackerman and Cook plotted the weight of inhibitor adsorbed on a given sample of powder versus the concentration of inhibitor in the benzene solution in equilibrium with the powder. This is the conventional adsorption isotherm. They placed a measured quantity of clean powder, containing no inhibitor, in contact with a solution containing a known quantity of inhibitor. The powder was agitated in contact with the solution until the adsorption was at equilibrium. After suitable experimental precautions were taken, the powder was reweighed, the increase in weight being the amount of inhibitor adsorbed. The final concentration of solution, in equilibrium with the powder, was then determined as the difference between its original concentration and the loss to the powder.

Desorption Isotherm

The powder which contained inhibitor in equilibrium with a given solution was then agitated with fresh portions of benzene until no more inhibitor could be leached off the powder. The amount which remained was plotted against the concentration in equilibrium with the powder before leaching with benzene (the same concentration plotted above) and this plot was called the desorption isotherm.

Hackerman and Cook also plotted the percentage corrosion reduction determined by the hydrogen evolution method on both the powder before adsorption and after desorption versus the equilibrium concentration after adsorption (again the same concentration just mentioned). They observed that the percentage corrosion reduction for a given set of powders containing a particular inhibitor gave a curve very similar to the adsorption isotherm. In other words, the amount of corrosion inhibition on the powder was proportional to the amount of inhibitor adsorbed.

This may be explained by assuming that the inhibitor forms a protective coating on the powder, which prevents access of the acid to the powder, and thus reduces the attack by the acid. Hackerman and Cook's data showed that the amount of inhibitor adsorbed on the powder did not increase without limit as the concentration of the inhibitor in the solution was increased, but rather that it rapidly built up to a limiting value.

It is generally believed that high molecular weight fatty acids, amines, etc., such as those investigated by the above mentioned authors, are adsorbed on solid surfaces until a unimolecular film of the fatty compound covers the surface. After this occurs no further adsorption is effected by increasing the concentration of the fatty compound in the solution.

It is generally accepted also that the polar part of the fatty compound (i.e., that part exclusive of the hydrocarbon chain such as the COOH, NH_2, OH) is oriented toward the solid surface, while the nonpolar part of the compound, which is the hydrocarbon chain, is oriented away from the solid surface. Inasmuch as the hydrocarbon residue is hydrophobic or water repellent, the ease with which the acid solution (in water) can penetrate the film of inhibitor and attack the metal is reduced. If the above explanation is correct, then it is logical that the greater the amount of powder surface covered by the water or acid repellent film, the greater will be the inhibition of acid attack observed.

It should be pointed out also that Hackerman and Cook did not report inhibitions of greater than 70-80 percent even when their powders were completely covered by adsorbed fatty molecules. This would imply that the protective film, even though covering the surface of the metal completely, cannot entirely prevent the penetration of acid to the metal.

Based on the above reasoning, it would be expected that the degree of corrosion inhibition would decrease when any of the inhibitor is desorbed from the powder. This was found to be the case. For this reason an effort should be made to obtain an inhibitor which is strongly adsorbed and which is desorbed only with difficulty. It also would be desirable for the adsorption equilibrium to be such that only a small amount of inhibitor in solution would be in equilibrium with a large amount on the metal powder. The reason for this is that the amount of inhibitor contained in solution is of no value per se, and is an economic loss in practical considerations.

Palmitic Acid

Initial studies were made on palmitic acid. This acid in its adsorption and desorption characteristics, and in its corrosion inhibition efficiency, follows the general behavior of the other long-chain fatty acids described above. It is rapidly adsorbed from low concentrations of its solutions and forms a monomolecular film, which was found to give about 65 percent reduction in the corrosion rate of the iron powder in acetic acid.

The experiments were performed in a manner somewhat different from that of Hackerman and Cook. Twenty grams of finely divided iron powder were placed in a four ounce bottle containing 100 ml of a benzene solution of the palmitic acid. The bottle was "tumbled" on a rotary wheel to give intimate contact of powder with the solution. One day sufficed for attainment of equilibrium.

The initial concentration of the solution, before adsorption, was varied in a series of experiments by dilution of various amounts of a stock solution of the acid in benzene. The final concentration of the acid was determined by decanting off the solution from the powder, evaporating the benzene, dissolving the residual acid in 50-50 ethyl alcohol and water, and titrating with 0.01 NaOH to the first pink of phenolphthalein.

The amount of acid adsorbed on the powder was calculated as the difference of the initial and final concentrations. To form a complete monolayer on twenty grams of powder required the acid equivalent of about three ml of 0.01 N base, which is less than ten milligrams of the palmitic acid. It was not felt

that such a weight increase on twenty grams of powder could be measured with accuracy.

The desorption experiments were performed by agitating the powders containing the adsorbed acid with one portion of 100 cc of fresh benzene. It was found that the maximum inhibition efficiency was thus reduced from 65 percent to 45 percent, indicating removal of a sizable fraction of the adsorbed material.

Experiments were carried out with solutions of a commercially available inhibitor in benzene in a similar manner, except that the concentration of the solutions was determined from the fluorescence of the solutions under ultraviolet irradiation. This inhibitor differed from the palmitic acid in that desorption was negligible. Again the maximum inhibition was around 65 percent, which was not decreased by the attempted desorption experiment.

These preliminary experiments appeared promising, and it was decided to investigate a large number of amines and acids whose structures were thought to be of interest. It is a common belief that the polar part of the inhibitor is the part responsible for its adsorption onto the metal. In view of this it was thought that compounds containing multiple polar groups would be of interest because of the possibility of adsorption at more than one site. The use of such compounds should increase the probability that a given site be occupied. If more than one site were occupied, this would necessitate the molecule of the inhibitor occupying a greater area on the metal surface, or conversely fewer inhibitor molecules would be required to cover a given area. Several dibasic acids, both aliphatic and aromatic, and a number of dibasic amines were investigated. The results will be discussed below.

Steric Factors

Mann and co-workers[5,6] carried out a great deal of experimental work on amines as inhibitors in acid solutions. They postulated that molecules of greater area, measured in a plane parallel to the surface of the metal on which the molecules are adsorbed, would be more effective as inhibitors than those of smaller area, other factors being equal. Thus, a branched chain amine (e.g., dibutyl or tributyl) should be more effective than straight chain amines such as n-octyl and n-dodecyl. The effective areas of these molecules may be calculated by the employment of molecular models such as the Fisher-Hirschfelder-Taylor type. A verification of these assumptions was attempted by measuring adsorption isotherms and corrosion inhibition efficiencies on both straight and branched chain amines of the aliphatic series.

Similar experiments also were conducted on aromatic amines containing groups of large areas such as phenyl, naphthyl, and diphenyl, in which one or more aryl groups were directly attached to the nitrogen atom.

Other Factors

Another factor of great importance in adsorption of polar molecules onto solids from nonpolar solvents is the solubility of the polar molecule in the solvent. According to Traube's rule of adsorption, in a homologous series, that compound will be adsorbed most strongly which has the least solubility. Thus, Hansen[7] measured the adsorption isotherms of several fatty acids from benzene onto charcoal, and found that the amount adsorbed (in moles) of the different acids was essentially the same when the concentrations of the acids were at equal fractions of their saturation solubility. In several (amine) cases, these findings are borne out by this study.

Another factor which was impossible to investigate conclusively was the basic strength of the amine nitrogen. It appears that adsorption is increased by an increase of the basic strength of the nitrogen, other factors being equal. This will be discussed in more detail.

Experimental Work

The principal difficulty in this work has been the lack of suitable analytical methods for determining adsorption isotherms. The method used for acids already has been described. It will be recalled that these acids were titrated with 0.01 N alkali to the phenolphthalein end-point. The uncertainty in this end-point is at best 0.25 ml, with a total amount adsorbed (calculated as a difference between two titrations) of only 3 to 5 ml. Thus, considerable scattering of the data may be expected.

For amines, the method of Fritz[8] was employed. This has the advantage that the amines may be directly titrated in the benzene solutions. The titrant is 0.01 N $HClO_4$ dissolved in glacial acetic acid. Gentian violet or crystal violet may be used as indicators, and the reproducibility of the method is about 0.05-0.1 ml. This method may be satisfactorily employed for all aliphatic amines, both straight and branched chain, and for primary aromatic amines such as aniline and its homologs and for β-naphthylamine. It can be used also for benzidine, tolidine, methylene dianiline, and its N, N, N′, N′, tetra alkyl derivatives, and for all of the isomeric phenylene diamines.

The method is unsatisfactory for a-naphthylamine or any of its derivatives because of the instability of these materials to oxidizing agents such as $HClO_4$. Nor can it be used for any of the secondary or tertiary aryl amines which were tried, or for any aromatic amines which contain ring substituted nitro groups. Such amines are too feebly basic because of the presence of adjacent strong negative groups to be titrated satisfactorily even with so strong an acid as perchloric.

After determination of the adsorption isotherm, the powders were dried and reacted with 1N acetic acid as previously described. Only one gram out of the twenty employed in the adsorption experiment was necessary for the corrosion test. The rest of the powder was then desorbed with fresh benzene, and corrosion tests run on the desorbed powders.

In most cases, the corrosion resistance of the powder was found to increase with the amount of material adsorbed on the powder, but the effective-

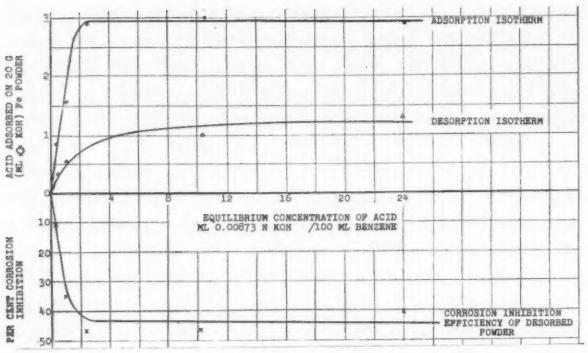
ADSORPTION ISOTHERM
DESORPTION ISOTHERM
ACID ADSORBED ON 20 G (ML. ◇ KOH) Fe POWDER
EQUILIBRIUM CONCENTRATION OF ACID
ML 0.0073 N KOH /100 ML BENZENE
PER CENT CORROSION INHIBITION
CORROSION INHIBITION EFFICIENCY OF DESORBED POWDER

Figure 1—Adsorption and desorption isotherms and inhibition efficiency of palmitic acid.

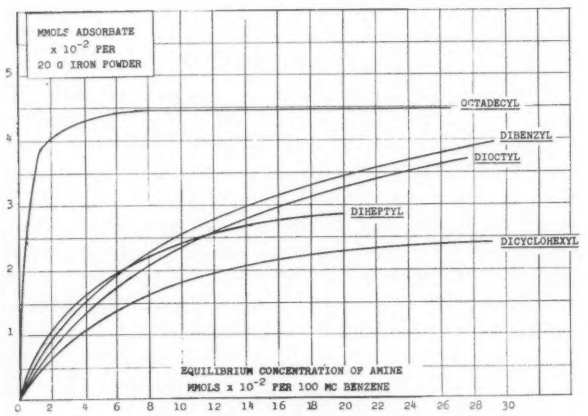

Figure 2—Adsorption isotherms of alkyl amines.

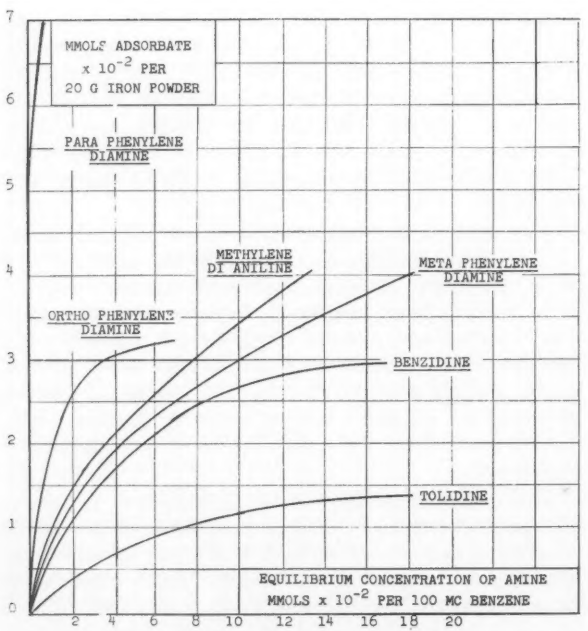

Figure 3—Adsorption isotherms of diamino compounds.

ness of different materials varied rather widely. Desorption of the powders generally decreased their resistance to acid attack. In some cases, however, the resistance increased for the aromatic diamines. Inasmuch as all of these solutions had discolored, it is believed that this increase in corrosion resistance was caused by adsorption of high molecular weight oxidation and/or polymerization products of the amines. For this reason no value can be attached to these measurements.

All of the materials employed in the adsorption experiments were in a high state of purity. The aliphatic amines were of the best grades obtainable from commercial sources and were not further purified. Liquid aromatic amines were used as received. All other aromatic amines were recrystallized from benzene or other suitable solvent, employing carbon black, and with the exception of the a-naphthylamine and its derivatives could be prepared quite pure. The latter materials always retain a slight color.

Treatment of the Data

Adsorption isotherms were plotted for the amines where satisfactory data could be obtained. These isotherms appear in Figures 1-3.

The data also were plotted according to a Langmuir equation in which the quantity (C/x) is plotted against C to give a linear plot. Here C is the concentration of adsorbate in solution in equilibrium with x on the adsorbent. The reciprocal of the slope gives the amount x_m which is the quantity of adsorbate required to form a monolayer. It is unlikely that most of the materials adsorbed in these experiments actually formed a monolayer (multilayers were probably formed), but the data can be fairly closely represented by such a plot and for comparison basis this method of plotting is used.

Table 1 presents all data for which both adsorption isotherm and corrosion rate measurements on the amines could be measured with reliability. The limiting value of x_m is shown as determined from a Langmuir-type plot. This value is listed for each compound in the first column opposite the name of the compound. In the next column is given the concentration required to effect an adsorption of 0.8 monolayer, as read off of the Langmuir plot.

The next two columns give the maximum amount of adsorption observed and the concentration in solution at that observed adsorption. The amount of adsorbed material is in hundredths of millimoles per twenty grams of iron powder. Concentrations are in hundredths of millimoles per hundred ml of benzene.

The last two columns list the maximum percent inhibition observed on the powder after adsorption of the inhibitor, and after desorption with a fresh portion of benzene. In evaluation of these data, strong adsorption is indicated by both a large value of the limiting value of x_m and by a low concentration required to obtain a relatively high proportion of the limiting value (i.e., by the value in the third column). The efficiency of the adsorbed film as an inhibitor is indicated by a high value in the sixth column, as well as by a small change between the sixth and seventh column or a high value in the seventh column.

Table 2 lists a number of amines for which no analytical method was available for determination of the adsorption isotherm. The powders after adsorption and drying were exposed to acetic acid, and the inhibition found on the powder exposed to the strongest amine solution was determined. The maximum concentration of amine originally in solution was of the order of 0.1 milliequivalent per hundred ml of benzene unless otherwise stated.

Table 3 lists a number of aromatic acids usually of two or more polar functional groups which were investigated. Most of these materials were strongly adsorbed on the powder, but none showed any inhibition when the powders were exposed either to HCl or acetic acid. Several of the acids (phthalic, terephthalic, and trimesic) also were dissolved in HCl and the solution contacted with iron powder. There was no difference in the reaction rate on the powder of the treated and untreated acid.

TABLE 1—Amines for Which Adsorption Isotherms Could Be Determined

Amine	Langmuir[1] Limiting adsorption	Concentration[2] for 0.8 Limiting Adsorption	Max. Adsorption[1] Observed	Concentration[2] in Equil. with this Adsorbate	Maximum % Inhibition on Powder	
					Before Desorption	After Desorption
p-phenylene diamine	9.3	0.4	8.1	0.5	38	..
m-phenylene diamine	4.8	8.3	3.75	8.25	23	..
o-phenylene diamine	3.8	2.0	3.15	2.85	30	..
Benzidine	3.7	7.9	2.90	7.10	28	..
o-tolidine	1.8	10.0	1.40	8.15	23	..
Methylene dianiline[3]	4.2	7.0	3.80	6.10	35	..
Tetramethyl methylene dianiline	..	..	0	10	22	..
Tetraethyl methylene dianiline	..	..	0	10	17	..
Aniline	..	..	0	10	0	..
Diethyl Aniline	..	..	0.2	10	15	..
β-naphthylamine	..	..	0.5	10	17	..
n-Octadecylamine	4.3	1.0	4.40	15.40	60	27
Diheptylamine	3.7	22	2.75	16.50	22	..
Di n-octyl	5.3	40	3.50	25.20	31	12
Dicyclohexyl	2.9	30	2.25	27.50	20	6
Dibenzyl	5.3	40	3.35	19.80	22	13
Triheptyl	..	..	..	..	40	..
Tribenzyl	..	..	0	20	10	..

[1] In millimoles per twenty grams of iron powder.
[2] In hundredths of millimoles per 100 ml of benzene at 25 C.
[3] Poor fit to Langmuir plot.

TABLE 2—Amines for Which Adsorption Isotherms Could Not Be Determined

Amine	Maximum Solution Concentration to Which Powder was Exposed[1]	Maximum % Inhibition on Treated Powder
a-Naphthylamine	10[1]	35[3]
Phenyl a-naphthyl	10	40[3]
Phenyl β-naphthyl	10	10
Triphenyl	Saturated[2]	0
Di-β-naphthyl p-phenylene diamine	Saturated[2]	18
Diphenyl p-phenylene diamine	Saturated[2]	5

[1] Meq x 100 per 100 ml benzene.
[2] Saturation value was less than one meq/100 ml benzene.
[3] Solutions discolored on standing.

TABLE 3—Aromatic Acids for Which Adsorption Isotherm Were Evaluated But Which Gave No Inhibition by Powder Tests in Acetic Acid

Acid	Solvent[1]	Remarks
Benzoic	Methanol	Strongly Adsorbed
p-ethoxybenzoic	Benzene	Strongly Adsorbed
m-hydroxybenzoic	Benzene	Measurably Adsorbed
2-chloroterephthaloyl benzoic acid	Benzene	Strongly Adsorbed[2]
5-chlorosalicylic	Benzene	Strongly Adsorbed
Phthalic	Methanol	Strongly Adsorbed
Terephthalic	Methanol	Strongly Adsorbed
Trimesic	Methanol	Strongly Adsorbed
β-resorcylic	Benzene	Measurably Adsorbed

[1] Concentrations of solution were in the range 1-20 x 10^{-2} meq per 100 ml solvent.
[2] Powder showed about 5 percent inhibition.

TABLE 4—Relationship Between Solubility and Adsorption for Various Compounds

Compound	Melting Point, Degrees, C	Solubility[1]	Adsorption[2]
Methylene Dianiline	92–93	63	4.2
Tetramethyl MeDiAnil	88–90	325	Less than 1.0
Tetraethyl MeDiAnil	ca.50	Very Sol.	Negligible
Benzidine	128–9	27	3.7
o-tolidine	126–8	31	1.8
o-phenylene diamine	102	29	3 8
m-phenylene diamine	63	40	4.8
p-phenylene diamine	140	11	9.3

[1] Milliequivalents per hundred ml of benzene at 25 C.
[2] Calculated from Langmuir plots at 25 C.

Discussion and Conclusions

Although the results of these investigations are not as conclusive as desired because of the lack of good data on many adsorption isotherms, some broad generalizations may be inferred. The amines will be considered first.

Effect of Solubility

According to Traube's rule previously stated, adsorption in a homologous series increases with decreasing solubility (usually with increased melting point of the adsorbate). This has been verified for several series. For the series methylene dianiline, and N, N, N′, N′ tetramethyl and tetraethyl homologues, the pertinent data are shown in Table 4. Also included are data on other homologous series for which data are available.

It will be seen that adsorption increases as solubility is reduced in each of the three series presented. The exception is the greater adsorption of the m-phenylene diamine over the ortho isomer. However, at equal concentrations in solution, the ortho isomer is more strongly adsorbed over the range through which it was measured. Furthermore, the increased amount of m isomer is less effective in inhibiting attack by the acetic acid, than is the smaller amount of o isomer as shown by the data of Table 1.

The solubility of methylene dianiline in benzene and its derivatives increases with molecular weight, a development which is somewhat unexpected. In aqueous media it appears that the reverse is true, as the order of inhibition of the hydrochloric acid solutions is in order of increasing molecular weight. The solubilities of benzidine and o-tolidine are in the

expected order as judged by their melting points. The amounts of adsorption are in the order of decreasing solubilities, and the amounts of inhibition on the powders are the same for the two materials, although twice as much benzidine as tolidine is required (see Table 1). These data will be discussed further.

An objection to the interpretation of these data is the fact that the solubility of the adsorbate in the acid, and the adsorption isotherm from acid solutions of inhibitor onto iron is not considered. These would be the quantities of real significance, but unfortunately, they cannot be measured by the methods presently available.

In this connection, it is of interest to consider the data on the three isomeric phenylene diamines. When solutions containing 0.07 N of the amine in N acetic were contacted with untreated iron powder, the rates of attack for the three amine solutions relative to uninhibited acid were 0.97, 0.67, and 0.78 for the o, m, and p isomers, respectively. When powders containing the maximum amounts of each of these materials adsorbed on them were contacted with uninhibited acid, the rates relative to untreated powder were 0.70, 0.77, and 0.62 for the o, m, and p isomers. When the treated powders were contacted with the inhibited acids, the rates relative to uninhibited acid on untreated powder were 0.66, 0.54, and 0.57 whereas the calculated values, assuming that inhibition on the powder and from the solution are cumulative, are 0.68, 0.52, and 0.48. This is fairly good agreement.

These data indicate that measurement of the amount of material adsorbed on the powder is not a sufficient criterion for prediction of inhibition efficiency. It will be seen, however, that the relative rates as judged from the measurements on the treated powder in pure acid are at least of the same order as the rates of the inhibited acids on the treated powders for the particular series discussed.

Steric Effects

It was hoped when this work was initiated that information could be gathered on the manner in which films of various materials formed on metals. It is known that fatty acids and amines form close packed monolayers, in which the hydrocarbon chains are in close proximity and stand nearly at right angles to the surface of the metal. Inasmuch as the cross sectional area of the hydrocarbon chains is known, the surface area of a metal powder may be calculated from a measurement of the amount of fatty acid adsorbed. Then, the same area of powder should adsorb more or less of another material depending on the cross sectional area of that material.

The area of the fatty chain is known to be 20.2 square angstrom units. The areas of other molecules adsorbed with different orientations to the metal surface may be calculated by means of scaled molecular models. Thus, benzidine has an area of about 80 square angstroms measured with both nitrogen atoms attached to the metal, or 15 square angstroms with one nitrogen attached and the plane of the rings perpendicular to the metal.

The Langmuir values for monolayer coverage are respectively 4.3 and 3.7 x 10^{-2} meq per twenty grams of iron powder as shown in Table 1 for octadecyl amine and benzidine. Based on the Langmuir value for octadecyl amine, (the known area of octadecyl amine = 20 square angstroms), then the calculated monolayer values for benzidine are 4.3 x 20/80 = 1.1 if the molecules lie flat with both nitrogen attached and 4.3 x 20/15 = 5.7 square angstroms if they stand on end. The actual value (3.7) is between these two extremes, which might be interpreted as meaning that the molecules are attached at only one nitrogen, and are tilted to the surface rather than perpendicular to it.

The areas calculated by models for o-tolidine are increased somewhat by the presence of the methyl groups giving a flat area of about 85 square angstroms and an upright area of about 20 square angstroms. The calculated adsorption maxima for monolayer formations are 1.05 and 4.3 x 10^{-2} meq for the two extreme positions. The actual adsorption maximum is 1.8 for tolidine, which is closer to the value for the flat lying molecule than was the case for benzidine. The adsorption of tolidine appears to be stronger in that both polar groups are partially involved. From melting point and solubility data, the two materials should adsorb about equally, with perhaps a slight edge for the benzidine. Actually, however, adsorption of benzidine is double that of tolidine. Apparently, the benzidine film is less tightly held, molecule for molecule, because the percentage reduction in corrosion by acetic acid is nearly the same for the two materials adsorbed on the powder, although there is only half as much of the tolidine. (A reduction of 23 percent is effected by adsorption of 1.4 m mol of tolidine, while a reduction of 28 percent requires 2.9 m mol of benzidine).

When similar calculations are carried out for the phenylene diamines and for the methylene dianiline, the observed amounts of material for monolayer formation are found to be greater than those calculated for the adsorbate lying flat with both nitrogens attached to the metal. The higher molecular weight amines (e.g., naphthyl, phenyl naphthyl, and diphenylene diamine derivatives) were chosen for this investigation because of their large molecular areas. Thus, if the molecules lie flat, only small numbers of them should be required for complete coverage of the surface. The only one of these amines for which a satisfactory analytical method was available was the B-naphthylamine. Although only a small amount of the material was adsorbed (see Table 1), a considerable inhibition was affected. Alpha naphthylamines are too unstable to light and air for satisfactory determination of their adsorption isotherms.

Other Aryl Amines

Powders were contacted with the other aryl amines listed in Table 2, but they were too weakly basic to titrate with $HClO_4$. These materials have large molecular areas and low benzene solubilities. Some have

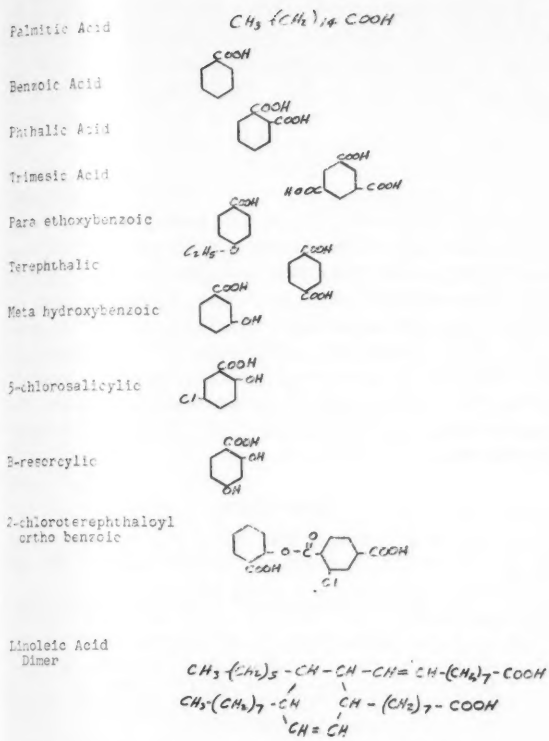

Figure 4—Structural formulae of acids mentioned in text.

multiple amino groups. In general, however, they either did not adsorb at all, or if they did, the adsorbed film was ineffective in protecting the powder from acid attack. It thus appears that when the basicity of the nitrogen is too weak, due to its proximity to several negative groups, the molecule is of no value as an inhibitor of acid attack.

Of the aromatic acids listed in Table 3, all were found to adsorb measurably and most were adsorbed considerably. However, none of the treated powders gave any inhibition. Also, experiments indicated that several of the acids (phthalic, terephthalic, and trimesic) gave no inhibition to attack when dissolved in acid solutions (of HCl).

It may be that these materials are ineffective because they are weak acids, and are un-ionized in the presence of stronger acids such as acetic or hydrochloric. Another possibility is that the polarity of the carboxyl or phenolic groups is not great enough to cause adsorption. This cannot be the complete explanation, however, as benzoic acid and its salts are well known as rust inhibitors. A considerably greater amount of information must be collected before satisfactory conclusions can be drawn on the aromatic acids.

With respect to aliphatic acids, the straight chain monobasic acids have been discussed previously. They are known to form close packed water-insoluble films with the polar group attached to the metal.

Experiments also were performed on a dimer of linoleic acid. This is not a straight chain acid. It has

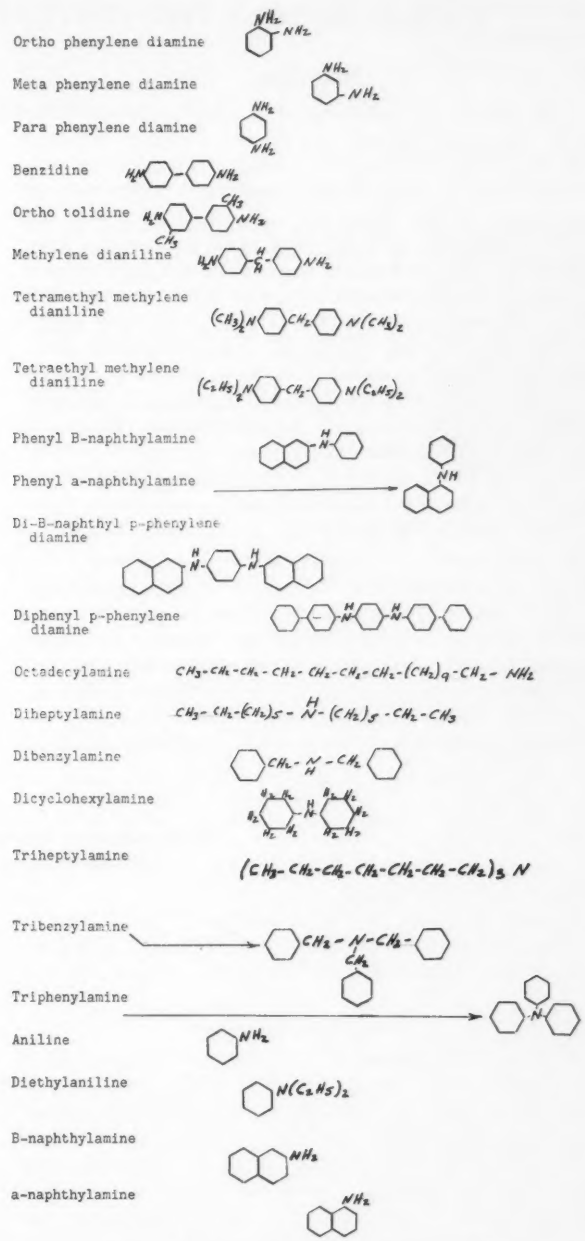

Figure 5—Structural formulae of amines mentioned in text.

two carboxyl groups separated by eighteen carbon atoms from one another, but the basic structure of the molecule is a cyclohexene ring with four side chains.

The formula of this compound may be found with those of other acids in Figure 4 (for amines see Figure 5). The adsorption isotherm of linoleic acid dimer was nearly identical with that of palmitic acid, and the attack by acetic acid on the powders containing it as an adsorbate was also very similar to that for those containing palmitic acid. It may be concluded that this material is attached to the metal by only one carboxyl group. Thus, in the case of the fatty acids, multiple polar groups do not indicate multiple

attachment. Data in the literature also bear out this conclusion.[9]

Branching

The effect of branching of the hydrocarbon chain also was investigated. Several secondary aliphatic amines were adsorbed—diheptyl, dioctyl, dicyclohexyl, and dibenzyl. Their adsorption isotherms are of similar shape. They do not adsorb strongly, nor is the adsorbed powder protected very much from acid attack. Based on the number of carbon atoms in the molecule, a secondary amine seems to be much less effective as an inhibitor than a primary amine of the same number of carbon atoms. Molecular models show that formation of tightly packed monolayers with such branched chain compounds is not generally as feasible as with straight chains. These are the same conclusions which were reported in a previous study[1] on the measurement of corrosion inhibition of amines in hydochloric acid.

Two tertiary aliphatic amines were investigated. The adsorption of triheptylamine was found to be very slight under the conditions of the experiment, while that of tribenzylamine was essentially zero. Both of these materials might be expected to adsorb more strongly than the corresponding diheptyl and dibenzylamines, on the basis of their molecular weights. The triheptylamine, nevertheless gave 40 percent inhibition on the powder, while the tribenzyl gave only 10 percent. Evidently, even small amounts of such high molecular weight adsorbates are of some value because of their low acid solubilities.

It is interesting to note that triheptylamine is a liquid while tribenzylamine is a solid at room temperatures. The adsorption of the tribenzylamine from benzene might be supposed to be greater, and its ease of desorption by aqueous acid less. Both materials have the same number of carbon atoms. With the triheptyl, however, a seven membered chain can be attained, while the tribenzyl gives a ring attached to a chain which cannot give as close a packing.

This conclusion is further substantiated by previous data.[1] Solutions containing 0.07 N amine in N HCl give by powder and by coupon tests respectively, 41 percent and 39 percent inhibition for the benzylamine, and 65 percent and 68 percent for the heptylamine.

References

1. C. C. Nathan. *Corrosion*, **9**, 199 (1953).
2. E. L. Cook and N. Hackerman. *J. Electrochem. Soc.*, **97**, 109 (1950).
3. E. L. Cook and N. Hackerman. *J. Phys. and Colloid Chem.*, **55** (4), 549 (1951).
4. E. L. Cook and N. Hackerman. *J. Phys. Chem.*, **56**, 524 (1952).
5. C. A. Mann, et al. *Ind. Eng. Chem.*, **39**, 910 (1947).
6. C. A. Mann, et al. *Ind. Eng. Chem.*, **28**, 159 (1936).
7. R. S. Hansen and R. P. Craig. *J. Phys. Chem.*, **58**, 211 (1954).
8. J. S. Fritz. *Anal. Chem.*, **22**, 1028 (1950).
9. Clare Markley. "The Fatty Acids," p. 186.

Any discussions of this article not published above will appear in the June, 1956 issue

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Effect of Long Cell Action on Local Cells*

By ROBERT POPE

Introduction

THE QUESTION of causes of corrosion on long structures was brought up at a recent meeting of an NACE technical committee. One of the main points considered was whether corrosion was being caused by local cells or by long cells (i.e., long line currents.) Where several corrosive tendencies are present, the corrosion is, of course, the cumulative effects of all these tendencies and no one tendency may be sufficiently pronounced to be classed as the principal cause of the corrosion. The relative effects of long cells and local cells can be shown by polarization diagrams.

Long cell action occurs on long structures where the structure is anodic in one area with respect to the same structure in another area more or less remote from the anodic area. It is usually caused by a change in the soil which affects the single potential (galvanic potential) of the structure with respect to the soil. The structure becomes anodic in the area where the single potential is less positive and it becomes cathodic where this potential is more positive. Because the structure itself acts as a short-circuiting conductor between the two areas, the action is similar to a local cell but on a very large scale. The short-circuiting structure equalizes the structure potential in the two areas and it does this by raising the structure potential in the anodic area and lowering it in the cathodic area. (Raising the potential means making it more positive with respect to surrounding soil and lowering it means making it less positive to surrounding soil.) Because the anodic area and the cathodic area are remote from each other, the effect is the same as partial cathodic protection in the cathodic area and reverse cathodic protection in the anodic area.

Where the long cell current is sufficient to neutralize the local cell anode current, complete protection is accomplished in the cathodic area, in a manner similar to cathodic protection. This case will not be discussed here as it has been covered previously.[1] The cases of partial protection and reverse protection are discussed below.

Figure 1 shows a circuit representing a local cell under the influence of long cell action. The anode and cathode are those of the local cell. LI(a) represents long cell current in the case where this current makes the local cell more positive with respect to surrounding soil and LI(c) represents long cell current where this current makes the cell less positive. The electrode for this current is in reality the structure at a point remote from the location of the cell under study. As in the previous paper,[1] PI represents cathodic protection current to stop the corrosion caused by the local cell. It will be observed that the long cell circuit is in parallel with the protection circuit, so that their effects are algebraically cumulative.

★Submitted for publication March 28, 1955. This paper is a supplement to an article by Mr. Pope entitled "Cell Currents and Potentials" which was published in the April, 1955 issue of *Corrosion* (pages 189t-194t).

ROBERT POPE—Retired in 1950 from Bell Telephone Laboratories where he had worked on developments and improvements in corrosion testing and preventive methods since 1934. He received a ME degree from Stevens Institute of Technology in 1920. Mr. Pope was employed by the Long Lines Engineering Department of American Telephone and Telegraph Company in charge of corrosion and electrical protection problems until 1924 when he was transferred to the company's Department of Development and Research. He was on the original NACE board of governors and is presently active on several NACE technical committees. Mr. Pope has presented several papers on various aspects of corrosion and contributed a chapter on Application of Cathodic Protection for the Corrosion Handbook.

Abstract

Long cell action can alleviate or aggravate corrosion caused by local cells depending on the location of the local cell. Corrosion conditions are aggravated in the anodic area of the long cell and more cathodic protection current is required to stop corrosion than would be required for the local cell alone. Corrosion conditions due to local cells are alleviated and conceivably could be eliminated by long cell action if the local cell were located in the cathodic area of the long cell. These effects are illustrated by polarization diagrams.

Less Positive Value

In the upper polarization diagram (Figure 1), the cell is shown as being made less positive by the long cell current, by a potential of LV. In order to accomplish this change of potential, the anode must be partially depolarized by sending into it from the soil a current equal to "LI to A." The cathode must be further polarized by sending into it a current equal to "LI to C." The total current being sent into the cell by the long cell effect is the sum of these currents, or LI. This long cell current sets up a new set of conditions indicated by the prefixed letter X. The anode is still losing current of the value XAI and consequently, corrosion is still taking place, but at a slower rate. The cathode current has increased to the value XCI. Additional current must be sent into the cell from the soil to attain minimum protection conditions.

To depolarize the anode to its open circuit potential, the current to the anode must be increased by a value "MPSI to A." Because the cathode must be at the same potential as the anode, it must be further polarized to the anode potential by feeding into it additional current equal to "MPSI to C." The total

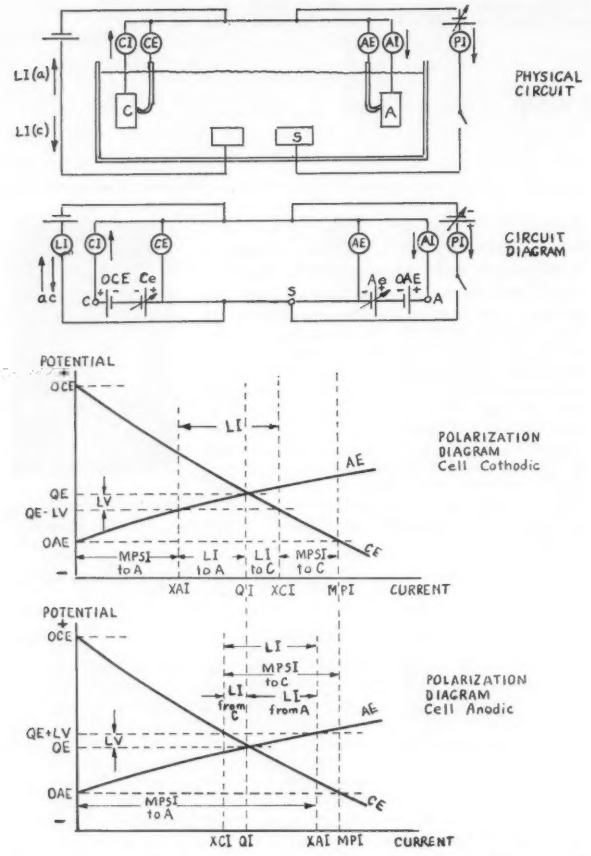

Figure 1—Circuit showing a local cell under the influence of long cell action.

current supplied by the protection circuit is the sum of these values. The minimum protection current, MPI, is the sum of the current from the long cell, LI, and the current from the protection circuit. Thus, the cathodic protection current required for minimum protection is less than would be required if there were no long cell action.

More Positive Value

In the lower polarization diagram, the cell is shown as being made more positive by the long cell current, by a potential of LV. The polarization of the anode is increased to "QE + LV" by additional anode current of "LI from A," making the total anode current, XAI. The cathode must be partially depolarized to "QE + LV" by reducing its current to XCI. This reduction in current is accomplished by drawing current from the cathode equal to "LI from C."

The total long cell current from the local cell is LI. Because the anode current is increased, the rate of corrosion is increased. To stop corrosion, current must be fed into the anode by the protection circuit, equal to XAI, which therefore becomes "MPSI to A." The cathode must be polarized from "QE + LV" to the open circuit potential of the anode, OAE. This requires additional cathode current equal to "MPSI to C."

The total current supplied by the protection circuit for minimum protection is the sum of "MPSI to A" and "MPSI to C," which in turn are equal to MPI plus LI. Thus the protection current required for minimum protection in this case is greater than would be required if there were no long cell action.

Resistance in the local cell circuit does not affect the results seriously. Such resistance can be taken into account by including resistance effects in the polarization curves as was done in Figure 7 of the original paper.[1]

Reference

1. Robert Pope. Cell Currents and Potentials. *Corrosion*, 11, 189t-194t, (1955) April.

Any discussions of this article not published above will appear in the June, 1956 Issue.

A Technical Note

A Simple Graphical Method for Checking The Adequacy of Stress Corrosion Specimen Dimensions Against Stress Concentrations*

By ROBERT H. HAY

Introduction

IN THE COURSE of stress corrosion evaluation of heat treatments for certain aluminum-magnesium alloys, it was found necessary to use a thinner test material (0.064-inch) than that customarily used (0.250-inch). Unexpected difficulties were encountered which were caused by failures of the thinner stress corrosion tensile test specimens at, or close to, the loading pin hole.

A sketch of half of a typical bar is shown in Figure 1 with dimensions symbolically indicated. Bars machined from 0.250 inch thick material had been designed to have a gauge-length cross-section of $\frac{1}{16}$ square inch which meant that if those bars machined from 0.064 inch thick material were to have the same gauge-length cross-section they would need to have a gauge width of 1 inch. This was considered unwieldly and the "constant" cross-sectional area was arbitrarily reduced to $\frac{1}{32}$ square inch to give test bars about $\frac{1}{2}$ inch wide for the thin material.

Failure of samples at the loading pin hole suggested stress concentrations at or near the holes. The shoulder fillets also could have given rise to such concentrations, but from Lemaire's[1] published curves of geometrical stress concentration factors for filleted shoulders it was found that stress concentration factors at the fillet would not exceed 1, or 1.2 at most, so that this possible source of trouble could be neglected. The loading pin holes, however, proved to be quite another matter.

Geometrical Stress Concentration Factors

Curves published by Frocht and Hill[2] give the geometrical stress concentration factors at holes in plate samples subject to an axial tensile load applied through smooth-fitting pins in the holes. From these curves it was determined that the 0.064-inch stress corrosion bars in question were subject to stress concentration factors of 2.3 to 2.7 and that the stresses near the holes exceeded those in the gauge-length. Working out a new design which would eliminate such stress concentrations led to the graphical construction of Figure 2 which provides a rapid check on the adequacy of any particular scheme of dimensions.

Referring to Figure 1,

Let S_g be the stress across the gauge section developed by the axial force P.

Let S_n be the "nominal" stress developed by P across the section AA.

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Abstract

The design problem created by the anomalous failure of thin stress corrosion sheet specimens at the loading pin holes is described. A simple theory taking into account stress concentrations due to holes and fillets is developed and is reduced to a convenient, easy-to-use graphical form which is explained by examples of its use.

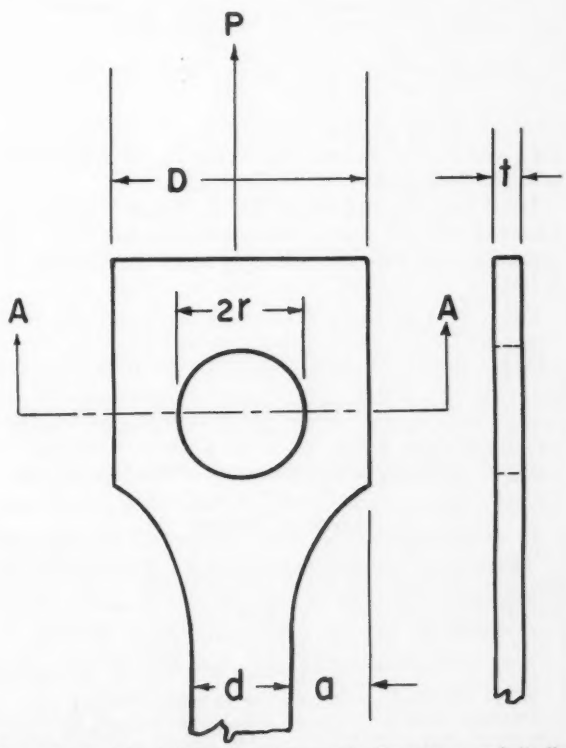

Figure 1—Sketch of half of test bar with dimensions symbolically indicated.

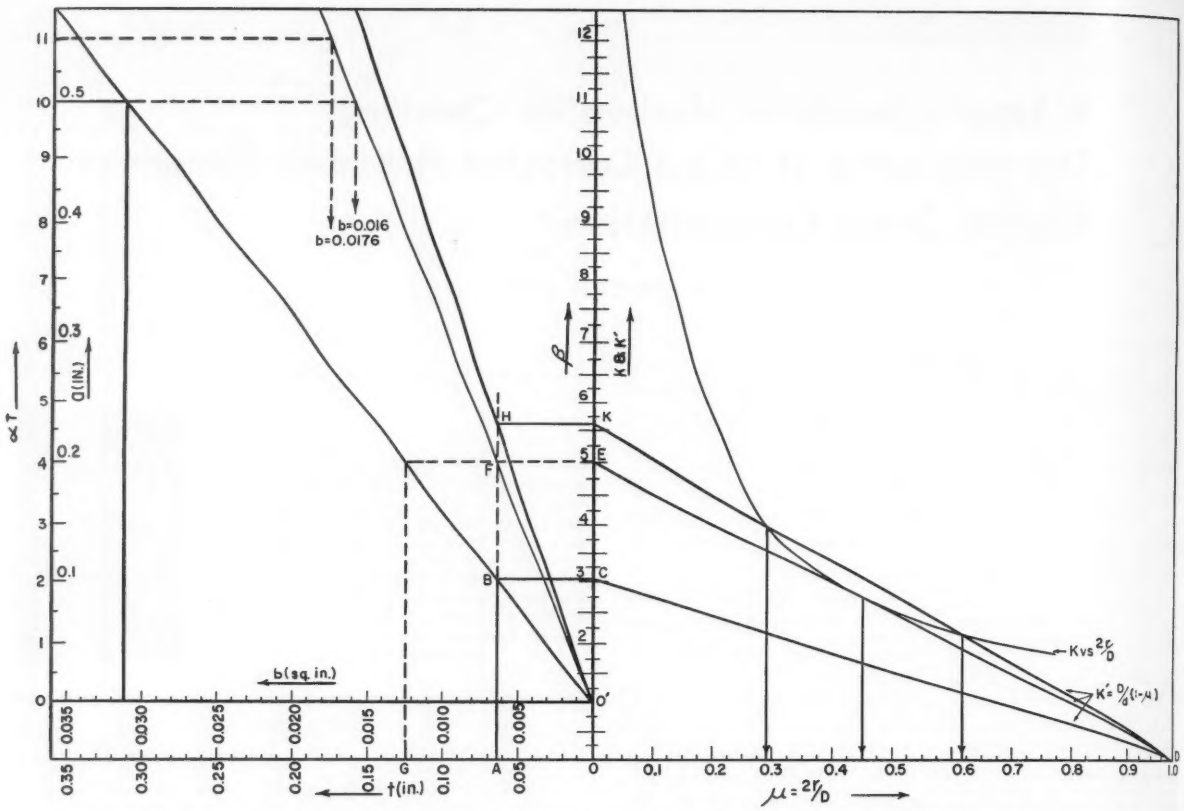

Figure 2—Graphical presentation of the constants and their relationships for designing sheet specimen stress corrosion test bars.

Let S_t be the actual stress developed by the stress concentration around the loading pin hole.

Then, $S_g = \frac{P}{td}$; $S_n = \frac{P}{(D-2r)t}$ and $S_t = kS_n$.

where k is the geometrical stress concentration factor given by Frocht and Hill.[2] Clearly, the test sample must be designed so that $S_g \geqslant S_t > S_n$.

Let $k' = S_g/S_n = P/dxt \times D(1-2r/D)\, t/p = D/d\,(1-\mu)$ where $\mu = 2r/D$, and is the critical dimensional ratio controlling stress concentration near the loading pin holes.

On a plot of k vs 2r/D such as those given in Reference 2, k′ vs μ would appear as a series of straight lines of negative slope passing through the point $\mu = 1$, $k' = 0$. This point is geometrical, of course, not physical. The right half of Figure 2 shows an appropriate curve of k vs μ from Reference 2 together with three k′ vs μ lines: DK, DE and DC.

Limit of Design

The line DE is tangent to the k curve and at the tangent point $k' = k$ for a single value of $\mu = 2r/D$; i.e., at this point $k/k' = 1$. But since

$$k/k' = \frac{S_t/S_n}{S_g/S_n} = S_t/S_g$$

it follows that $S_t = S_g$ at this point which thus becomes the limit of design. All k′ lines lying above this tangent line will cut the k curve at two points giving a minimum and a maximum value for μ. Within these limits $k/k' < 1$ and $S_t < S_g$; i.e., the design is "safe." For all k′ lines lying below the tangent line the ratio $k/k' > 1$ and $S_t > S_g$; i.e., the design is "unsafe."

The choice of k′ line is determined by its slope, $D/d = \beta$. These quantities are related to each other and to the thickness of the specimen as follows:

$$D = d + 2a \quad \text{and} \quad d \times t = \text{constant} = b.$$

Therefore:

$$D/d = \beta = \frac{b/t + 2a}{b/t} = 1 + \frac{2a}{b}t = 1 + \alpha t.$$

In Figure 2 the k′ lines are drawn so that their intercepts on the ordinate axis are their β values. Therefore the axis of abscissae, or μ, can be extended positive to the left as an axis of t and the lines plotted for $\beta = 1 + \alpha t = 1 + \frac{2a}{b}t$ in this quadrant. These lines will originate at 0′, the point where $t = 0, \beta = 1$, and their slopes will be determined by the values of "a," and "b," the specimen cross-sectional area in the gauge-length. In the case cited "t" was fixed as 0.064 inch and "a" and "b" had been chosen as 0.5 inch and 1/32 square inch, respectively. Therefore,

$$\beta = 1 + \frac{2a}{b}t = 1 + \frac{2 \times 1/2}{1/32} \times 0.064 = 1 + 32 \times 0.064 = 3.048$$

From the above value of β the line O′B is obtained. This line can be used to give scales on which to lay

out a "b" axis to the left from O′ and an "a" axis vertically along the left-hand margin of the figure. The scales chosen are indicated.

For 0.064 inch sheet (point A on the t-axis) it is clear that $b = 1/32$ square inch and $a = 0.5$ inch will not give a "safe" design because the projection of B to C gives the k′ line CD, which is well below the tangent line and therefore "unsafe." The limiting tangent line, DE, gives a β-value of 5 which intercepts the line AB at F. O′F is thus the limiting "a vs b" line. The proper value for "b" with "a" held at 0.5 inch is at once seen to be 0.016 square inch—just about half of the arbitrarily chosen value of $1/32$ square inch. Alternatively, if yield strength of the material, extensometer range or some other such consideration sets $1/32$ square inch as the required value for "b," and "a" is held at 0.5 inch, point G on the thickness axis can be determined at once as the minimum allowable specimen thickness.

Actual Working Limits

This design "nomogram" neglects the effects of bearing stress and the stress concentrations arising "just because the hole is there."[3] The limiting cases therefore are probably not quite "safe" and actual working limits should be chosen from lines such as O′H and KD which would give a value of 0.575 inch for "a," when "b" is set at 0.016 square inch.

The dimensions actually chosen for the re-designed specimen bars gave a line between O′F and O′H. The bars have performed very well in subsequent testing with no recurrence of the anomalous failure at loading pin holes so that these neglected factors are probably of an order of magnitude smaller than the one considered.

References

1. D. A. Lemaire. Report SM 126, Division of Aeronautics, Ministry of Supply, Australia.
2. M. M. Frocht and H. N. Hill. *Jour. Appl. Mech.*, **7**, A-5 (1940) March.
3. Procedure for Experimental Stress Analysis, **V**, No. 2, p. 56, Addison-Wesley Press Inc., Cambridge, Mass., 1948.

Any discuss.ons of this article not published above will appear in the June, 1956 issue

DISCUSSIONS ON TECHNICAL ARTICLES ARE SOLICITED

Discussions on technical articles published in Corrosion will be accepted for review without invitation. Discussions must be constructive, accompanied by full substantiation of fact in the form of tables, graphs or other representative data and be submitted in three typewritten copies.

Authors of discussions are asked to supply one copy of figures suitable for reproduction and will be sent on request a copy of the NACE Outline for the Preparation and Presentation of Papers.

Discussions will be reviewed by the editor of Corrosion and will be sent to the author of the paper discussed for his replies, if any. Publication will be in the Technical Section with full credit to the authors together with replies. Discussions to papers presented at meetings of the association may be submitted in writing at the time of presentation or later by mail to the editorial offices of Corrosion, 1061 M & M Bldg., Houston 2, Texas.

A Practical Corrosion Service Program*

By B. J. PHILIBERT

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Abstract

A corrosion engineer's work is both corrective and preventive. Doing better preventive work lessens corrective work required. A wide knowledge of materials and fabrication with good specifications to cover both is required of the corrosion engineer. Frequently a corrective corrosion or metals problem is the heart of an engineering problem. When a specific problem is isolated, the engineering problem usually must be solved before the materials problem. A simple substitution of materials of construction is frequently inadequate. By the accumulation and distribution of helpful preventive information, the corrosion engineer establishes his value as a consultant and recognition of his worth follows.

Introduction

ONE OF the complaints most frequently made by corrosion engineers is that they are not saving management as much money as they are capable of doing. Such a situation comes about in many cases simply because they have been unable to sell management on the value of an overall corrosion engineering program as a necessary part of their company's activities. Many corrosion engineers feel their activities are little appreciated and, sometimes, barely tolerated.

A well defined positive program frequently can overcome such resistance. Use of the program outlined in this paper can accomplish such a goal.

Point 1—Preventive Work

A corrosion engineer's work should include preventive work as well as corrective work. The better the preventive work is done, the less corrective work will be required.

Operating and maintenance groups of plants continually make installations or replacements of items of equipment. In many cases, an item depleted in service is replaced with a duplicate that is similar in every respect. According to the proposed plan, such items should be considered in the light of modern engineering design criteria for materials of construction before replacement. Many times, a more resistant material can be chosen.

The corrosion engineer normally receives a wealth of information on the physical properties and chemical resistance of materials of construction. Much of this may come to him from manufacturers of materials or equipment. Maintenance personnel would hesitate to make an application on the limited information in such a recommendation. The corrosion engineer, however, is in position to collect, evaluate and distribute such information to those who would find it useful. They would be prepared, therefore, with useful information from a known source prepared by a recognized authority. Such information could be used with confidence by the person whose job it is to select materials of construction. The corrosion engineer's approval gives the recommendation validity.

An example of this occurred not too long ago in a Texas plant where the maintenance department had purchased cast iron bell and spigot pipe to handle an organic chloride off-gas. Prior to installation of the pipe, the corrosion engineer's routine distribution of a recommendation of silicon iron for such service was received. There was still time for a substitution to be made. The cast iron pipe, then in surplus, was successfully used for water lines. Because of the issue of the corrosion engineer's bulletin, a considerable amount of embarrassment was avoided. Also, a substantial amount of money was saved. The plant's confidence in the corrosion engineer's recommendations was enhanced considerably through this experience.

Point 2—Knowledge of Materials

A wide knowledge of materials of construction, methods of fabrication and good specifications to cover both, is required of the corrosion engineer. These must be considered in the light of the corrosion resistance available in the finished structures.

The corrosion engineer cannot fulfill his function satisfactorily merely by making a direct comparison between corrosion rates on different materials, leading to the substitution of one material for another. He must be familiar also with the composition, the physical properties and the methods of handling various materials in order to consider their overall suitability. Many times a particular material may be found to be satisfactorily corrosion-resistant, but because of unsuitable physical properties, cannot be considered for the application.

In applying a particular material of construction to an item of equipment, the fabrication procedures necessary to provide final properties must be considered. Usually, the procedures must be examined and suffi-

★ Submitted for publication January 31, 1955. A paper presented at the Eleventh Annual Conference, National Association of Corrosion Engineers, Chicago, Illinois, March 7-11, 1955.

ciently defined to assure that the final fabrication itself, as well as the base material, incorporates adequate resistance to the corrosive environment.

It is well recognized that most fabricating shops attempt to produce finished products of high quality, according to their own standards. It is necessary to determine, by thorough investigation, whether such standards fulfill the requirements of the particular problem with which one is dealing. In the welding of a stainless steel vessel, for example, the shop may make every effort to produce welds of maximum strength and pleasing physical contour. It may well be that in this particular component, the primary objective was to acquire a unit incorporating maximum corrosion resistance. The two goals are not necessarily identical. If maximum corrosion resistance is the particular quality which is critical two things must be done. It must first be specified that this quality is required, and then it will be necessary to verify that the procedures to be used to attain the final conditions will be such as will result in these properties.

Many times, in writing a requisition which will be forwarded to a Purchasing Department for purchase of equipment, the use of an ASTM specification is considered adequate. Sometimes, this may be true. A large part of the time, however, this will not be the case. Additional requirements above and beyond the limitations of ASTM specifications must be defined and included as an addition to the specification.

An example is to be found in the case of a large purchase of seamless, heavy wall stainless steel tubing according to ASTM A-269. Some ASTM specifications include a test to uncover the presence of susceptibility to intergranular corrosion. Some specifications may also carefully specify internal surface conditions meeting close tolerances. In this particular case, $40,000 worth of stainless steel Type 304 tubing was found completely unsuitable for the service for which it was intended because of a rough internal surface condition and the presence of a substantial amount of carbide precipitation throughout. The material still met all the requirements of ASTM A-269. In such a case the addition of an intergranular corrosion test, the prohibition of a "sinking" operation in the formation of the tubing, and the requirement for an internal surface condition within reasonable tolerances should have been added to the specification. It should be pointed out that this is not an exceptional case.

Purchasing groups can buy only what they are asked to buy. They will derive much more satisfaction from purchasing something which fills the need of the user. They cannot accomplish this unless the material required is properly specified to them. Such a specification can be made only by a person who is familiar with the object's end use and the means by which it is produced. This procedure must be followed in order that the specifier may clearly delineate procedures which are or are not acceptable, and list tolerances and tests which will disclose the acceptability of the material under the specification.

Point 3—Engineering Problems

Very frequently, a corrective corrosion or metals problem is only one phase of an engineering problem. The engineering problem usually must be solved before work can be done on the question of metals. Simple substitution of materials of construction is often inadequate.

Because exceptions to this very general rule will suggest themselves, some examples in which the rule applies will be mentioned before elaborating upon the rule itself.

An example of this is to be found in the case of a Triplex pump used for pumping aqueous ammonia. The pump was designed for operation at 3,000 psig pressure. After a period of shutdown for some months, this pump was put into use on aqueous ammonia which sometimes contained a small percentage of chloride contamination. Also, there was a new operating crew in the plant. Over a considerable period of time, the packing in the pump, and frequently the pump rods, had to be replaced at intervals of three days to three weeks.

After some months of such service, the corrosion engineer was asked to assist with this problem. One of the rods from the pump was sent to a metals laboratory. From a physical inspection, the general appearance suggested a severe acid attack. A plating of lead was found on the rod in the section where it reciprocated within the stuffing box. This lead had been mechanically removed from a leaded type packing. This was not the packing originally specified, but had been substituted by the operating personnel. From the appearance of the rod alone, corrosion appeared to be the culprit.

Upon inspecting the pump in the field, however, and observing the operation, some other conditions presented themselves. It was apparent that lubrication of the pump was not being effected. The procedure for repacking the pump rods and establishing and maintaining lubrication was rewritten to emphasize the importance of lubrication. The same type of rods and the same type of packing originally used were re-installed in the pump with increased emphasis on the importance of lubrication. The pump was put back in service. The pump then operated for eight weeks before the first shutdown became necessary. At that time, the rods were inspected and showed no effects of corrosion. A maintenance saving of approximately $10,000 per year was effected, not counting the production time loss chargeable to the original high maintenance rate.

The corrosion engineer is, first of all, an *engineer.* Many times, he will find that by reducing each of his problems to their fundamentals and considering the engineering aspects, other contributing factors such as velocity, impingement, etc., are more responsible for his troubles than direct electro-chemical effects.

Point 4—Distribution of Information

By the accumulation and distribution of helpful preventive information, the corrosion engineer establishes his value as a consultant to the operating departments of his company. Recognition of his worth follows.

In any program, making information available is one

of the most important functions of a corrosion engineer's work. He should put this information into simple, brief form which will be read and referred to. He should make recommendations concerning most frequently used applications. Most important of all, he should be sure such information is given in a form which makes it readily available to the reader. It must be understandable.

Most of the information required on different materials of construction and their corrosion resistance is readily available. Producers of metals have spent vast sums of money developing information on this subject. This information, plus the corrosion engineer's judgment, will dictate the choice of material for such bulletins. His job is to be a receiving center. He should condense this information and put it into a more useable form. At the same time, he will refresh his knowledge and remove any doubt he may have concerning the matters he covers.

One of the very helpful things which can be done is the preparation of recommended design procedures for such groups as maintenance divisions of the company. In most cases, such groups have a minimum of technical personnel. Some good data on the welding of stainless steel to produce maximum corrosion resistance, for instance, would be a real help to most shop groups.

In a recent experience, an idle section of a plant was put to a new use. This section had been constructed entirely of Type 316 stainless steel. In making the change-over, some piping changes were required. Field welding was used.

Shortly after start-up of the new plant, failure of some of the pipe lines was encountered. Upon examination in the field by the corrosion engineer who was called to assist, it was observed that all failures were occurring at welds. Sections of welds were removed and taken to the metals laboratory of one of the stainless steel producers. By analysis of the metal in the weld, it was discovered that columbium was present. In checking further, it was found that plant welders liked to use Type 347 electrode because of its ease of application.

At the suggestion of the plant engineer, a memorandum was prepared for distribution to the welders which gave a clear picture of good practice in stainless steel welding. A meeting of the welders themselves was held with a good "chalk talk" and plenty of illustrations, to make clear the hazards involved in a promiscuous choice of electrodes.

This course of action proved to be very effective. The men took a new interest in their work, and considerable pride in producing stainless steel weldments of high quality. It might also be pointed out that the corrosion engineer's part in this activity enhanced his value to the plant very substantially.

Point 5—Reduction of Repair Bills

Effective work by a corrosion engineer can save his company a large percentage of their maintenance and repair bills each year.

The author has found from experience that it is often difficult to put a dollar value on some of the services of a corrosion engineer. From things which can be evaluated, however, it is known that it is possible in a large organization to make savings as great as six figures. Aside from the direct savings made by effective work on a particular problem, there is always an added advantage. The consciousness of a particular thing as a problem is increased in the minds of all who have any part in it. This invariably results in closer attention being paid to the particular problem and generally results in more effective operation. Many times, this alone leads to a satisfactory solution without any further work.

Conclusion

The corrosion engineer possesses a wealth of information of substantial value to many of the others who work around him. Much information is available to him from producers which has been developed at a cost far in excess of what his own company could afford to spend to obtain similar information. The help of such producers in dealing with problems is indispensible and generally free. The men in these organizations are usually the best specialists in their lines. They are just as interested as the corrosion engineer in preventing misapplications of the materials which they produce and fabricate.

Proper application of materials of construction from the standpoint of corrosion resistance, good specifications to cover these applications, and effective preventive and corrective corrosion service will save most companies a large percentage of their maintenance costs. These savings will more than pay for good corrosion programs.

Acknowledgment

Permission to publish this article given by S. S. Johnson of the Development Division is gratefully acknowledged. The author also thanks F. L. La Que and L. W. McIlrath for reviewing this article.

Any discussions of this article not published above will appear in the June, 1956 issue

The Effect of Cold Work and Heat Treatment On the Rate of Dissolution of Pure and of Impure Aluminum in Acids and Bases*

By M. E. STRAUMANIS and Y. N. WANG

Introduction

TAMMANN WAS OF the opinion that the rate of dissolution of a metal invariably increases after the metal has been subjected to cold work, and that the rate drops again to the values of a soft (annealed) metal if the internal stresses are relieved by heat treatment.[1] A review of the literature shows, however, that there are many instances where the rate is not influenced or even decreased by the cold work of the respective metal. A good review of the subject with a critical approach was given by Evans[2,3] and by Harwood.[4]

Investigations with cold worked and heat treated aluminum have been made by Bailey,[5] Czochralsky and Schmid,[6] Herzog,[7] Maass and Wiederholt,[8] Tammann and Neubert,[1] Rohrman,[9] Cagliotti,[10] Roald and Streicher,[11] and others.[2]

The conclusions drawn by Tammann already have been mentioned. Wiederholt, in a study of the dissolution of 99.9 percent aluminum (the balance was mainly iron) in 0.65 N hydrochloric acid, found a strong increase in rate after the recovery of the metal by annealing. Mears,[12] in summarizing the results, states that in many cases of exposure, cold work does not appreciably affect the resistance to corrosion of a wide variety of aluminum-base alloys. He added that cold work seemed to stimulate the attack of aluminum by non-oxidizing acids to some extent.

In view of these uncertain results, it was thought advisable to re-check the effect of cold work upon the rate of dissolution of aluminum using for this purpose purest aluminum and copper-aluminum alloy samples. Hydrofluoric acid and barium hydroxide were chosen as the solutions to be used because these electrolytes are capable of dissolving the protective films on the metal.[13,14] Such is not the case for hydrochloric acid, where a protective skin, although porous, always covers the surface of the metal.[13] This skin may cause deviations in the rate of cold worked and recrystallized aluminum. Barium hydroxide was selected because it produced a somewhat higher dissolution rate than sodium or potassium hydroxide, and because the aluminum plates after the tests showed a shiny appearance as if the plates had been polished.[15]

Materials Used

The aluminum sheet used in this investigation for the determination of the rate of dissolution in hydrofluoric acid was a 99.99 percent pure sample obtained

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Abstract

The rate of dissolution of a 99.99 percent pure, one way cold rolled aluminum sheet as received was determined in 1 N hydrofluoric acid, and compared with the rates obtained with a 400 to 575 C recrystallized aluminum specimen of the same quality. No significant differences in rates could be detected. There also was no difference in the dissolution rates of surfaces cut under different angles with respect to the direction of cold rolling.

The same dissolution behavior was observed with 99.998 percent pure aluminum in 0.5 N barium hydroxide solutions; there was no difference in rates of the cold rolled and recrystallized samples, except for cold hammered samples, which showed higher rates. Differential heat treatment of aluminum alloys (with 1 and 2 percent copper), however, produced different rates; the samples heat treated at 200 C exhibited lower rates of dissolution.

The conclusion reached is that cold work itself evidently does not influence the rates of dissolution of aluminum in hydrofluoric acid and in barium hydroxide solutions. However, the effect of cold work may be felt indirectly by creation of cracks and fissures in the metal, which increase the rate of dissolution. Changes in the constitution of the aluminum due to the heat treatment if the metal is impure, may also influence the rates of dissolution.

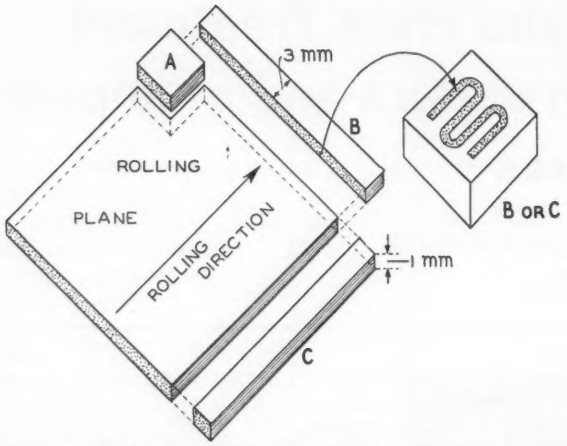

Figure 1—Sketch showing the sectioning of specimens A, B and C from the cold rolled sheet of 99.99 percent aluminum. Specimen B has a surface 1 x 50 mm; surface of attack is perpendicular to the rolling direction and to the rolling plane. Specimen C is the same as B except parallel to the rolling direction and perpendicular to the rolling plane. Samples D, E and F are recrystallized A samples (parallel to rolling plane).

from the Aluminum Company of America. The analysis supplied with this material claimed the following impurities: 0.0015 percent Si, 0.0007 percent Fe, 0.0004 percent Cu and 0.0007 percent Mg. This aluminum (designated as H-18 temper) was fabricated from a 2.5-inch x 12-inch ingot which was scalped, heated to 204 C and rolled to 0.375 inch slab. The slab was annealed for two hours at 343 C and then cold rolled to a final thickness of 0.04 inch (approximately 1 mm).

The aluminum used for dissolution in barium hydroxide was produced by the French Company "Compagnie de Produits Chimiques et Electrometallurgiques d'Alais, Froges et Camargue." The specimen was 99.998 percent pure with the following major impurities: 0.0009 percent Si, 0.0002 percent Fe, and 0.0003 percent Cu. The rate determination experiments in barium hydroxide were made previously by Brakss.[16]

It was of interest to compare the dissolution characteristics of these two very pure metals. As the dissolution rates of the French aluminum in purest hydrochloric acid (reagent grade) were already known,[17] only the rates of the aluminum of the American Company had to be determined. For this purpose a one square cm specimen was cut from the aluminum sheet. It was annealed at 470 C for one hour to relieve stresses caused by cold work and later was slowly cooled in the furnace. Then the specimen was ground, polished and mounted in Bakelite.

The rate of dissolution in 2 N hydrochloric acid was determined under conditions as nearly identical as possible to those of the previous work.[17] The experiments were continued (at 25 C) for 44 hours; an average rate of hydrogen evolution of 18.6 cubic mm per square cm per minute was observed. The French aluminum produced a rate of only 0.558 cubic mm per square cm per minute (1 cubic mm of H_2 is equivalent to 0.000803 mg of dissolved aluminum). This comparison shows that the French aluminum was purer as also the analysis had indicated.

Rate Determination in Hydrofluoric Acid

Dissolution Apparatus

The determination of the rate of dissolution of aluminum in hydrofluoric acid was based on the collection and measurement of the volume of hydrogen gas liberated according to the reaction:

$$Al + 3H^+ \rightarrow Al^{3+} + 1\frac{1}{2}\ H_2$$

or:

$$Al + 3HF \rightarrow AlF_3 + 1\frac{1}{2}\ H_2 \qquad (1)$$

The sketch of the apparatus for dissolution of the metal and hydrogen collection has been published previously.[18] The equipment consists of a 200 cc Erlenmeyer flask to hold the aluminum sample and the acid for dissolution (100 cc), a stirring mechanism with a mercury seal, a gas burette to collect the evolved hydrogen, and a constant temperature water bath (25 ± 0.1 C).

In order to protect the glass from attack by hydrofluoric acid, the inside wall of the flask was coated with a layer of Sunoco 1290 brown wax.(1) This material was selected because of four waxes tested it showed both the best adherence to the glass and the best resistance to the attack of hydrofluoric acid.

The vertical glass rod of the stirring mechanism was wedged at the lower end into an ebonite rod, to which the aluminum sample (mounted in Bakelite) was fastened at a 45 degree angle to the rod's rotational axis. The sample was rotated clockwise with a constant speed of 200 revolutions per minute. The stirrer was driven by a variable speed motor and an electronic motor speed controller.(2) Glass joints were used wherever possible to prevent hydrogen diffusion through the rubber connection parts, and the apparatus was tested from time to time for tightness. The flask in which the dissolution occurred was completely submerged in the water of the thermostat. The rate of dissolution was calculated from the volume of the evolving hydrogen reduced to standard conditions and was expressed in cubic mm per minute per square cm of the dissolving surface area.

Preparation of Specimens

Various specimens were prepared in order to determine the difference in the rates of cold worked and of recrystallized aluminum. The rates on surfaces laid in different directions through the cold rolled aluminum sheet also were established.

From the sheet of the American aluminum described previously, a wide strip was cut and etched with 1 N hydrofluoric acid to reveal the direction of rolling. After that the respective specimens were cut from the sheet. They had 0.5 and 1 square cm surface areas to be exposed to the action of the acid. They were mounted in Bakelite, smoothed with emery paper, and finally polished with levigated aluminum oxide.

(1) Sun Oil Company, Philadelphia, Pa.
(2) S. K. Heller Co., Baltimore, Md.

Figure 1 shows how the samples were cut from the sheet. The "A" specimens had a surface prepared for the attack of the acid parallel to the rolling plane.

The surface of attack of the "B" specimens were perpendicular to the rolling plane and to the rolling direction. They were prepared as follows. A strip of aluminum 3 mm wide and 50 mm long was cut from the sheet as shown in Figure 1 and was filed to a uniform thickness of 2 mm. Then the strip was folded and mounted in Bakelite. The area of the aluminum strip exposed to the acid was 50 square mm.

The surface subjected to attack of the "C" specimens was parallel to the rolling direction and perpendicular to the rolling plane. The mounting was the same as in the case of "B" samples.

The "D" specimens were recrystallized "A" samples which had been heated in a vacuum furnace at 400 C for one hour. Neither change of dimensions, nor deformation of the specimens could be noticed after the heat treatment.

The "E" specimens also were recrystallized "A" samples. They were heated, however, at a temperature of 575 C (one hour).

The "F" specimens were made in the same way as the D and E samples, except that the 1 square cm surface area was etched by 1 N hydrofluoric acid before the plates were placed into the vacuum furnace.

Results

It was necessary at first to determine the rate of dissolution of the cold worked aluminum in the chosen concentration of 1 N hydrofluoric acid, and to see whether the procedure of mounting in Bakelite had any influence on the rate of dissolution. The latter experiments showed that the mounting procedure did not influence the rate. The reaction (1) usually started with a short induction period lasting from 30 to 50 minutes. Next there followed a flat maximum dissolution period (about 80 minutes in the 1 N acid) and finally the rate of the reaction gradually declined.

The figures obtained in one run with a "B" sample are shown in Table 1. It was determined previously that the average maximum rate of dissolution of the cold rolled aluminum specimens in 1 N hydrofluoric acid was 303 cubic mm per square cm per minute.[19] However, prior to making the rate determinations with other cold worked samples, the rate produced by the "A" samples was determined anew, and a slightly higher value of 319.0 cubic mm per square cm per minute was found. The difference is only +5 percent and is, thus, completely within the error limits of rate measurements, which may frequently produce differences as high as 30 percent between parallel runs. The rate 319 was used as a basis for comparison with the rates obtained with other cold worked and heat treated specimens.

The experiment of Table 1 was continued for a longer time than shown in the table in order to ensure that the maximum rate of dissolution had been passed. The average maximum rate is shown as a final result.

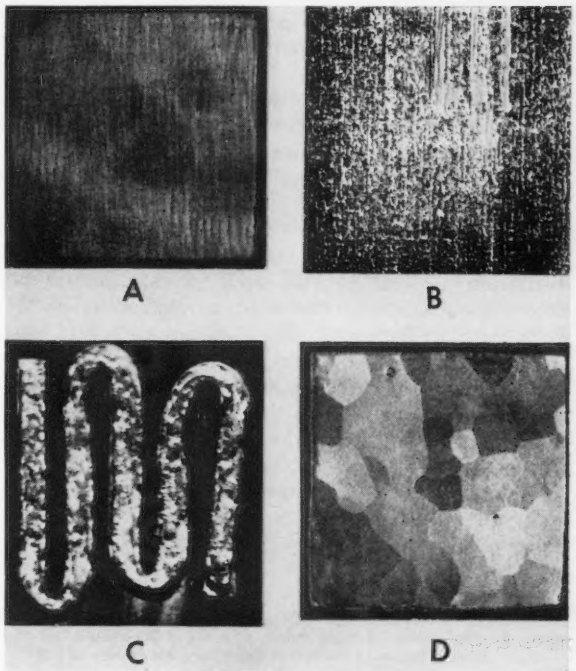

Figure 2—Samples before and after dissolution. Specimen "a" is a cold rolled aluminum sample before immersion in 1 N hydrofluoric acid. Specimen "b" is the same sample after the corrosion experiment. Specimen "c" is a severely attacked sample "b" (section perpendicular to the rolling direction). Specimen "d" is a recrystallized sample after the corrosion experiment. Magnification is about 4X.

TABLE 1—Rate of Dissolution of the Aluminum Specimen B in 1 N HF at 25 C.[a]

Time in Minutes	Volume of H_2 in cm^3	$\triangle$[b] in cm^3	Rate in mm^3/cm^2 min
0	0	...	0
10	0.86	0.86	172
20	2.23	1.37	274
30	3.68	1.45	290
40	5.06	1.38	276
50	6.51	1.45	290
60	7.89	1.38	276
70	9.23	1.34	268
80	10.80	1.57	314[c]
90	12.25	1.46	292[c]
100	13.88	1.63	326[c]
110	15.60	1.72	344[c]
120	17.31	1.71	342[c]
130	18.65	1.34	268
140	19.99	1.34	268

[a] Section was perpendicular to the Rolling Directions; Specimen's exposed surface was ½ cm^2. Hydrogen volume was reduced to standard conditions.
[b] $\triangle$ Represents difference in volume of two subsequent readings.
[c] Used for average: 324. One mm^3 is = 0.000803 mg of Al.

The appearance of the samples before and after the dissolution experiment is shown in Figure 2. No intercrystalline attack was observed on the plates. The results obtained with the different samples are summarized in Table 2. Usually two runs were made with each specimen; the averages are given in the table.

The discussion of Table 2 will be given later, but even a quick look shows that the effect of cold work on the rate of dissolution of aluminum was completely within the error limits.

Rate Determinations in Barium Hydroxide[3]

Technique

Samples were cut directly from an ingot of purest French aluminum. Discs were made 15.9 mm in diameter and 4 mm thick. The surface intended for the dissolution experiment was smoothed with a file and then polished with a polishing wheel and levigated aluminum oxide. The sides and the back of the plate were protected from the attack of the base by rubber insulation.[14] The apparatus used for rate determinations was essentially the same as that used in the work with hydrofluoric acid. The stirring rate was 120 revolutions per minute.

To relieve all the stresses that might still be in the prepared specimens, the aluminum discs, embedded in aluminum oxide, were heated in a hydrogen atmosphere at 500 C for 40 hours. Then the discs were quenched in cold water and one surface of each was polished again.

To check the influence of deformation, samples were prepared from a rolled and a hammered metal. The cold rolled discs were cut from a sheet that was obtained by rolling down an aluminum block of 23 x 25 x 18 mm to a thickness of 2 mm in 15 passes.

The samples severely deformed by hammering were obtained as follows: (1.) An aluminum block 18 x 18 x 18 mm was hammered on four edges with a clean hammer on a clean anvil so that a cylinder with a diameter of 18 mm and a height of 20 mm was obtained; the concave ends of the cylinder were then filed flat (height 18 mm). (2.) This cylinder was now hammered down to a height of 14 mm (hammering direction was perpendicular to the previous one) and a diameter of 21 mm. (3.) By hammering the distorted cylindrical wall of this disc (perpendicularly to the previous direction), the cylinder, as described under point 1, was restored.

The plates for the dissolution experiments were cut from the severely deformed ends of this cylinder.

After these experiments the same plates were subjected to heat treatments at 450-500 C for 15 hours and quenched.

Finally, the plates from the hammered metal were heated at 500 C, and then in the course of 11 hours they were slowly cooled to 200 C.

[3] Performed by N. Brakss.[16]

TABLE 2—The Effect of Cold Work and Heat Treatment on the Rate of Dissolution of 99.99 Per Cent Pure Aluminum in 1 N Hydrofluoric Acid at 25 C.

Specimen	Type of Treatment and Section	Max. Average Rate in $mm^3/cm^2min.$	Difference in % Based on Rate 319
A	Cold rolled (H-18 temper) Previous results Present results	(303)[a] 319	
B	Cold rolled, perpendicular to rolling plane and direction	347	+ 8
C	Cold rolled, perpendicular to rolling plane and parallel to rolling direction Average (cold rolled Al)	363 343 or 322 of all 4 results	+12
D	A, annealed at 400 C, 1 hour	331	+ 3.6
E	A, annealed at 575 C, 1 hour	295	— 7.5
F	A, annealed at 575 C, 1 hour, etched in HF Average (recrystallized Al)	337 321	+ 5.3

[a] This value is for comparison and is not in the average of 343.

TABLE 3—Dissolution Rates of 99.998 Percent French Aluminum and Alloys Subjected to Different Mechanical and Heat Treatment in 0.5 N $Ba(OH)_2$ Solution at 25 C

Metal	Mechanical Treatment	Heat Treatment	Rates in mm^3/cm^2min	
			Single	Average
Al	None	500 C, 40 Hours, quenched	21.3 19.4	20.4
Al	Cold rolled	None	21.2 21.1	21.2
Al	Cold rolled	500 C, slowly cooled	21.5 20.7	20.7
Al	Cold hammered	None	28.2 25.2	26.7
Al	Cold hammered	500 C, 15 Hours, quenched	21.5 22.7	22.1
Al	Cold hammered	500 C, slow cooling	20.9 21.1	21.0
Al + 1% Cu	None	500 C, 56 Hours, quenched	102.4 107.7	105.0
Al + 2% Cu	None	500 C, 56 Hours, quenched	98.8 101.1	100.0
Al + 1% Cu	None	500 C. → 200 C, 52 Hours	80.5 80.5	80.5
Al + 2% Cu	None	500 C. → 200 C, 52 Hours	79.5 81.1	80.3

Results

The rate of dissolution in 0.5 N barium hydroxide solution was much slower than in hydrofluoric acid. The reaction also started with an induction period followed by a very flat maximum. Consequently, the duration of the dissolution experiments was longer than in hydrofluoric acid. The rate of reaction was followed by collecting the hydrogen volume liberated during the reaction:

$$2Al + Ba(OH)_2 + 2H_2O \rightarrow Ba(AlO_2)_2 + 3H_2$$
$$Al + OH^- + H_2O \rightarrow AlO_2^- + 1\frac{1}{2}\ H_2$$

The maximum average rates obtained with the heated and quenched aluminum samples are summarized in Table 3. The table also contains data obtained with the deformed metal.

The French aluminum was very pure. For that reason the heat treatment could not affect the state of impurities in the aluminum, and hence influence the rate of dissolution of differently treated specimens. In the past, however, for the establishment of the effect of cold work, impure metals or alloys often were used and then were heat treated. The effect observed was attributed to cold work or to the release of internal stresses by the heat treatment. Therefore, it was of importance to determine experimentally how different kinds of heat treatment would influence the rate of dissolution (for instance, for an aluminum-copper alloy.) For this purpose two alloys, with 1 and 2 weight percent of copper were prepared. Plates made of these alloys were heated, as described above, for 56 hours and quenched in cold water. One polished surface of each plate was then subjected to corrosion in 0.5 N barium hydroxide solution (see Table 3).

After the experiments the plates were removed from the dissolution apparatus and cleaned. The sur-

faces were evened with a file, polished, and again heated at 500 C for 10 hours. Then the samples were slowly cooled to 200 C and tempered at this temperature for 52 hours. Such plates exhibited in the 8 to 10 hours long dissolution experiments a lower rate (Table 3) than the quenched specimens. This is in agreement with the results of Roald and Streicher,[11] obtained with pure and impure aluminum in hydrochloric acid. Table 3 definitely shows that cold work, with the possible exception of hammering, does not affect the rate of dissolution of purest aluminum in barium hydroxide solutions. However, various kinds of heat treatment of aluminum-copper alloys may produce differences in rates as high as 20-25 percent. It seems strange that aluminum alloys with 1 and 2 percent copper with the same heat treatment exhibit almost identical rates of dissolution. This is in accordance, however, with previously published results that the rates of dissolution of impure aluminum in bases increase only proportionally to the $\log_{10}$ of the impurity concentration.[20] In addition, rate fluctuation in such experiments are very common. Fluctuations resulting from undetermined causes also may explain why the rates produced by purest aluminum, as shown in Table 3, are so low. The rates obtained previously with samples from the same material were much higher.[15]

Discussion

The conclusions which may be drawn from the dissolution rate determinations in hydrofluoric acid (Table 2) are quite clear. The samples B and C show a somewhat higher dissolution rate than the sample A. All three specimens were cut from the same aluminum sheet with the only difference being that the surface subjected to dissolution had a different orientation as to the rolling plane and rolling direction. However, the border line of the Bakelite-insulated metal in samples B and C enclosed only ½ square cm, but was 5 times as long as in the case of the A samples (Figure 2, a, b and d). As the borderline was always somewhat more strongly attacked by the acid than the middle of the sample,[21,22] the higher rate produced by specimens B and C may be explained by the borderline effect (see Figure 2c). Thus, there seems to be no influence of orientation of the dissolving plane relative to the direction of the fibres in the cold rolled aluminum on the rate of dissolution.

Furthermore, there was no difference in the rates of dissolution within the limits of error (which may be about ± 10 percent in the present experiments) between the cold rolled and recrystallized samples. If the rates of all cold rolled specimens and of all recrystallized ones are considered, there is no difference at all (322 cubic mm per square cm per minute versus 321). The cold rolling evidently does not influence the rate of dissolution of aluminum in hydrofluoric acid.

The same situation prevailed for the dissolution rate of the samples of the highest purity French aluminum in barium hydroxide solutions (Table 3); there was no difference in the rates of dissolution of cold rolled and recrystallized aluminum. However, the severely hammered aluminum sample displayed a slightly increased rate of dissolution, which might well be attributed to the presence of slip planes, or to microscopic or submicroscopic shear cracks, in which the base intruded producing a slightly augmented rate of dissolution.[23] Evidently no such cracks were formed in the metal during the one way rolling process.

During the heat treatment of the hammered metal complete recrystallization occurred. It is very possible that the access from the surface to the larger cracks through the slip planes and slip bands (the metal of which usually is more strongly attacked by the etchant[24]) was closed by the heat treatment as the metal of the slip planes recovered.

The evidence for such a process is as follows: Although no cracks could be observed microscopically on the hammered aluminum plates after the dissolution experiments, submicroscopic cracks and slip bands nevertheless should have been present. This is known to be true because of the highly deformed and diffuse border lines of the crystallites observed on the surface of the plates. The distortion of the border lines occurred during the cold work through slip.[25]

According to Averbach[26] the slip lines, planes and bands formed have some qualities of grain boundaries. During the recrystallization process (15 hours at 500 C, see Table 3) nuclei usually are formed along these slip planes. If not then they already were present in form of severely strained subgrains in the deformed metal.[27,28] The subsequent grain growth then occurs by boundary migration which spreads over the slip bands and planes, causing them to be annihilated.[29,30,31] Thus, this process may contribute substantially to the decrease of the rate of dissolution of the previously hammered but then heat treated aluminum. However, other possibilities of explanation, not yet explored, are also possible.

A distinct effect of differential heat treatment on the rate of dissolution of aluminum-copper alloys in barium hydroxide solutions was observed. This effect can be explained as follows. Inasmuch as the solubility of copper in aluminum at 500 C is approximately 4 percent, all the copper of the 2 and 1 percent alloys at that temperature was in solid solution. After quenching, the copper remained in solid solution, or it precipitated subsequently in small amounts in a highly dispersed form as $CuAl_2$ in the alloy.[32] In either case, if such an alloy were then subjected to dissolution, small copper particles would appear on the surface and produce many local cathodes. Thus the rate of hydrogen evolution was appreciably increased in comparison with that of the pure metal.[33]

During the prolonged annealing process at 200 C, a number of particles of the dispersed phase started to grow at the expense of other smaller ones with the final result that the total number of particles and the total surface of the dispersed phase decreased as the outcome of the heat treatment. With the decrease of the number of active local cathodes, the rate of dissolution naturally decreased.

A similar explanation of the effect was proposed also by Roald and Streicher.[11] These examples show

that in case of impure metals or alloys, the cold work effects, if any, frequently may be overlapped by effects caused by a change in the constitution of the metal as a consequence of the heat treatment applied.

The experiments with the heat treated aluminum alloys also are in agreement with the results obtained by Rohrman[9] with 99.95 percent aluminum. The quenched samples, after a prolonged exposure to hydrochloric acid, displayed a higher rate of corrosion than the slowly cooled samples. The potentials of all samples, however, were practically identical.

No such identical potentials were observed with other metals such as iron and steel.[3] It is difficult to say why the results of Tammann and Neubert[1] differ from those mentioned above. Unfortunately, those authors did not indicate how long the corrosion experiments with the cold rolled and annealed specimens were continued (plates of only 0.1 mm in thickness were used). It is possible that the result would be different if the plates were dissolved for a longer time in the acid. This is because of the behavior of the outermost layers of a metal is different from the inside layers.

The experiments indicate that the rate of dissolution of aluminum is influenced not so much by the cold work itself as by some consequence of cold work (i.e., the formation in the metal of microscopic cracks, fissures or crevices.) Heat treatment affects the rate of dissolution in so far as certain consequences of cold work are removed and in so far as changes in the distribution of impurities or alternations in the form and volume of segregations in the metal are produced. This is correct if water soluble corrosion products ($AlCl_3$, AlF_3, $NaAlO_2$, $Ba(AlO_2)_2$) are formed. But if corrosion of cold worked aluminum proceeds in nearly neutral or neutral solutions, the result may be different because of formation of insoluble corrosion products in even the finest microscopic fissures of the metal. As the corrosion products ($Al(OH)_3$, basic aluminum salts) have a larger volume than the metal itself, the cracks or fissures are widened by the presence of newly formed corrosion products. More of the corrosive liquid can now enter, and the fissure widening and corrosion process continues destroying the cold worked aluminum piece.

It seems strange that the energy stored in aluminum during the rolling process does not influence the rate of dissolution of the cold worked metal. The reasons for this are as follows: (1.) At least a portion of the accumulated energy may be released during the long storage, and at relatively low temperatures where recrystallization does not occur at all.[34] (2.) The strain may not be distributed evenly through the whole sample but may be accumulated in small portions of it;[34] a slightly increased rate of dissolution may result from this situation. (3.) The residual energy of cold work may be insufficient to produce a rate substantially different (outside of the limit of errors) from that of a soft (annealed) metal.

Acknowledgment

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References

1. G. Tammann and F. Neubert. *Z. anorgan. Chemie,* **207,** 87, 88 (1932).
2. U. R. Evans. Metallic Corrosion, Passivity and Protection. Longmans, Green and Co., New York, 1948, p. 433.
3. M. T. Simnad and U. R. Evans. *Trans. Farad. Soc.,* **46,** 175 (1950).
4. J. J. Harwood. *Corrosion,* **6,** 249, 290 (1950).
5. G. J. Bayley. *J. Inst. Met.,* **9,** 79 (1913); *J. Soc. Chem. Ind. Tr.,* **39,** 118 (1920).
6. J. Czochralsky and E. Schmid. *Z. Metallk.,* **20,** 2 (1928).
7. E. Herzog. These, Lille, 1932, p. 32.
8. E. Maass and W. Wiederholt. *Korrosion u. Metallschutz,* **5,** 265 (1929).
9. F. A. Rohrman. *Tr. Electrochem. Soc.,* **66,** 229 (1934).
10. W. Cagliotti. *Atti Congresso Chim, pura appl.,* **4,** 442 (1933).
11. B. Roald and M. A. Streicher. *J. Electrochem. Soc.,* **97,** 283 (1950).
12. R. B. Mears. Corrosion Handbook (H. H. Uhlig, Editor). J. Wiley and Sons, Inc., New York, 1948, p. 39, 48.
13. M. E. Straumanis and Y. N. Wang. *J. Electrochem. Soc.,* **102,** 304 (1955).
14. M. E. Straumanis and N. Brakšs. *J. Electrochem. Soc.,* **95,** 98 (1949).
15. M. E. Straumanis and N. Brakšs. *J. Electrochem. Soc.,* **96,** 21, 23, 310 (1949).
16. N. Brakšs. Dissertation, "The Corrosion of Purest Aluminum and Its Binary Alloys by Bases," Riga 1944, p. 94.
17. M. Straumanis. *Korrosion u. Metallschutz,* **14,** 1 (1938).
18. M. E. Straumanis and P. C. Chen. *J. Electrochem. Soc.,* **98,** 234 (1951).
19. M. E. Straumanis and Y. N. Wang. *J. Electrochem. Soc.,* **102,** 382 (1955).
20. M. E. Straumanis and N. Brakšs. *J. Electrochem. Soc.,* **96,** 310, 314 (1949).
21. U. R. Evans. Metallic Corrosion, Passivity and Protection. Longmans, Green and Co., N. Y., 1948, p. 496.
22. R. B. Mears and U. R. Evans. *Trans. Farad. Soc.,* **30,** 417, 1934.
23. H. R. Copson. *Corrosion,* **10,** 124 (1954).
24. M. Straumanis. *Z. physik. Chem. A,* **147,** 161, 182 (1930).
25. C. S. Barrett. Structure of Metals. McGraw-Hill, New York, 1952, p. 339.
26. B. L. Averbach. Cold Working of Metals. Am. Soc. Metals, Cleveland, 1949, pp. 262, 263.
27. P. A. Beck and P. R. Sperry. *J. Appl. Phys.,* **21,** 150 (1950); P. A. Beck. *J. Metals,* **4,** 979 (1952).
28. R. D. Heidenreich. *Bell Syst. Techn. J.,* **30,** 867 (1951).
29. P. A. Beck, P. R. Sperry and H. Hu. *J. Appl. Phys.,* **21,** 420 (1950); P. A. Beck and P. R. Sperry. *J. Metals,* **188,** 468A (1950); P. A. Beck. *Acta Metall.,* **1,** 230 (1953).
30. T. V. Cherian, P. Pietrokowsky and J. E. Dorn. *AIME Trans.,* **185,** 948 (1949).
31. W. Boas. Physics of Metals and Alloys. J. Wiley, New York, 1949, p. 92.
32. E. H. Dix, Jr., R. H. Brown and R. D. Williams. *Corrosion,* **7,** 109 (1951); E. H. Dix, Jr., *AIME Trans.,* **137,** 11 (1940).
33. M. E. Straumanis and P. C. Chen. *Corrosion,* **7,** 229, 236 (1951).
34. P. A. Beck. Annealing of Cold Worked Metals. *Phil. Mag Supplement,* **3,** 345, 371, 397 (1954).

Any discussions of this article not published above will appear in the June, 1956 issue.

Publication 56-4

Report on Rigid Polyvinyl Chloride

A Report of NACE Technical Unit Committee T-6A on Organic Coatings and Linings for Resistance to Chemical Corrosion*

Abstract

The development of rigid polyvinyl chloride has opened an entirely new field in structural applications. Rigid polyvinyl chloride has sufficient structural strength, impact resistance and hardness to replace metals in many forms. At the same time, polyvinyl chloride offers such inherent properties as extreme corrosion resistance, heat and electrical insulation, dimensional stability, low maintenance, ease of fabrication, light weight and good aging.

Unplasticized vinyl chloride has exceptional resistance to acids, alkalies, alcohols and aliphatic hydrocarbons. The resin is non-oxidizing, insoluble in most chemicals and self-extinguishing. The maintenance of these properties in the final product depends upon the modifiers used in specific formulations.

Recommendations are made regarding the use of rigid polyvinyl chloride in various media. Corrosives in which tests were made include three concentrations of sulfuric acid, three concentrations of hydrochloric acid, two concentrations of nitric acid, two concentrations of phosphoric acid, acetic and glacial acetic acid, fatty acids, hydrogen peroxide, sodium hypochlorite, chromic acid, two concentrations of sodium hydroxide, potassium hydroxide, water, five salts, three fats and oils and nine solvents. Mechanical properties are given for Type I and Type III polyvinyl chloride.

Fabrication of rigid polyvinyl chloride is discussed in detail. Topics considered in this connection include machining methods, molding techniques and joining techniques.

Foreword

COMMITTEE T-6A was organized for the purpose of assembling and disseminating to the corrosion engineer, factual and quantitative data on the performance and limitations of the various organic materials that are successfully used in coatings and linings. While every attempt is made to be factual in the coverage of application and chemical resistance tables and physical properties, it nevertheless should be recognized that changes in compounding formulations of organic materials for coatings or linings enhance or detract from their inherent corrosion resistance characteristics. Under such circumstances, these reports and recommendation lists must be viewed as showing average properties only. The possibility of changes in chemical and physical characteristics as produced by various manufacturers or applicators of the material should be kept in mind.

Definitions

Rigid polyvinyl chloride is a linear chain compound produced by the polymerization of the vinyl chloride monomer. Various molecular weights are available, depending on physical properties desired. The vinyl chloride polymer is also copolymerized with such materials as acrylonitrile, vinylidene chloride, etc., to modify or improve physical properties. Rigid vinyl materials are made up for the most part of high molecular weight vinyl chloride polymers unmodified by plasticizers or similar materials.

The Thermoplastic Structures Division of the Society of the Plastics Industry (SPI) has set up the following designations for rigid polyvinyl chloride:

Type I—Normal impact optimum chemical resistant

Type II—Medium impact—chemical resistant (between 1.0 and 5.0 izod impact)

Type III—High impact—chemical resistant (greater than 5.0 izod impact)

Summary of Properties

The development of rigid polyvinyl chloride has opened an entirely new field in structural applications. Rigid polyvinyl chloride has sufficient structural strength, impact resistance and hardness to replace metals in many forms. At the same time, polyvinyl chloride offers such inherent properties as extreme corrosion resistance, heat and electrical insulation, dimensional stability, low maintenance, ease of fabrication, light weight, and good aging. The exceptional resistance of vinyl chloride resin to corrosive chemicals, moisture and abrasion has led to the use of unplasticized resin for the production of unsupported rigid products.

Unplasticized vinyl chloride resin has exceptional resistance to acids, alkalies, alcohols, and aliphatic hydrocarbons. The resin is non-oxidizing, insoluble in most chemicals and self-extinguishing. The maintenance of these properties in the final product, depends upon the modifiers used in specific formulations. Most types of vinyl chloride resin available are soluble in ketones to a limited extent. A wide range of pigments can be used in vinyl chloride resin com-

* R. McFarland Jr., Hills-McCanna Co., Chicago, Illinois, chairman.

pounds to obtain an unlimited variety of colors. Clear vinyl chloride resin formulations tend to discolor upon prolonged exposure to sunlight even though the best stabilizing compounds are used.

Use

In the industrial construction field rigid vinyl chloride resin is used primarily for unreinforced piping, filter parts, exhaust systems, duct work, rain gutters, and down-spouts. Rigid vinyl chloride resin can be formed by such standard methods as extrusion, compression and injection molding, and calendering. Final fabrication of the end product can be accomplished by deep drawing, welding, drilling, sawing and threading. The successful employment of these fabrication methods requires an understanding of the limitations of thermoplastic materials.

Forms Available

The original PVC polymer is in a fine white powder form. From this state it may be molded or extruded into sheets of 1/16 inch or more in thickness, or may be used to form rods, tubes, ducts, pipes, etc.

Effect of Compounding

Rigid vinyl resins—shapes or sheets—usually are uncompounded except for minor pigmentation and stabilization. This is done in order that the excellent chemical and physical properties will be retained.

Resistances

Mechanical properties of rigid polyvinyl chloride are given in Table 1. Chemical properties are listed in Table 2.

Water

Rigid vinyls have a water absorption of 0.10 percent at 25 C for 24 hours. This appears to be the only effect of exposure to water. Continuous immersion in tap, distilled, or sea water for a period of years does not appear to introduce changes.

TABLE 1—Mechanical Properties of Rigid Polyvinyl Chloride

Properties	Units	DATA	
		Type I Polyvinyl Chloride	Type III Polyvinyl Chloride
Specific Gravity	.....	1.47	1.47
Compressive Strength	Lbs/sq in	11,000	8,000
Tensile Strength	Lbs/sq in	6,500	5,800
Flexural Strength	Lbs/sq in	13,500	11,000
Izod Impact	Ft lb/in notch	0.8	15.0
Coloring Possibilities	.....	Unlimited	Unlimited
Thermal Conductivity	Cal/cm²/sec/degree C/cm X 10^{-4}	3.7	4.5
Heat Distortion	Degrees F	170	160
Specific Heat	Cal/gm/degree C	0.25	0.23
Heat Expansion	Per degree C X 10^{-5}	6	9
Heat Expansion	Per degree F X 10^{-5}	.....	.....
Ignited by Flame	.....	Very difficult	Very difficult
Burning Rate	In/min	Self-extinguishing	Self-extinguishing
Light Stability	.....	Excellent	Excellent
Water Absorption	Percent 24 hr at 25 C	0.10	0.10

Inorganic Acids

The rigid vinyls consist almost entirely of vinyl chloride polymers. They are more resistant to inorganic acids than any available material. Even concentrated sulfuric acid has little effect on Type I materials. This is the most chemical resistant type of rigid polyvinyl chloride.

Organic Acids

Acetic, formic and similar organic acids have some effect on vinyl chloride resins. Type I rigid vinyl is little affected by 80 percent acetic acid at room temperature. Increased temperature increases the attack by organic acids. This material is not recommended for handling glacial acetic acid.

Fatty Acids

Fatty organic acids have little effect on rigid vinyls. If the acids are hot and are retained for long periods, there may be a softening effect at the liquid level. This is caused by oxidation of the fatty acids to ketonic and similar oxygenated structures.

TABLE 2—Chemical Properties of Rigid Polyvinyl Chloride[1]

Corrosive	Resistance
Inorganic Acids:	
Sulfuric, 10%	R
50%	R
Concentrated	LR
Hydrochloric, 10%	R
20%	R
Concentrated	R
Nitric, 10%	R
Concentrated	R[2]
Phosphoric, 10%	R
86%	R
Acetic, 10%	R[2]
Glacial	NR
Fatty Acids	R[2]
Oxidizing Agents:	
Hydrogen Peroxide	R
Sodium Hypochlorite	R
Chromic Acid, 40%	R
Alkalies:	
Sodium Hydoxide, 20%	R
70%	R
Potassium Hydroxide	R
Water:	
Tap	R
Distilled	R
Sea	R
Salts:	
Sodium Chloride	R
Sodium Phosphate	R
Sodium Dichromate	R
Ferric Chloride	R
Copper Sulfate	R
Fats and Oils:	
Mineral	R[3]
Animal	R[3]
Vegetable	R[3]
Solvents:	
Alcohols	R
Aliphatic Hydrocarbons	R
Aromatic Hydrocarbons	LR
Ketones	NR
Ethers	NR
Esters	NR
Chlorinated Hydrocarbons	NR
Phenol	NR
Turpentine	LR

[1] Code is as follows: R—Recommended; NR—Not Recommended; LR—Limited Recommendation.
[2] At Room Temperature.
[3] May be some attack at liquid level on prolonged exposure to elevated temperature.

Alkalies

Rigid vinyls are resistant to inorganic alkalies in all concentrations.

Salt Solutions

The rigid vinyls are resistant to all common salts and should not be affected by them even on continuous immersion for periods of many months or years. Complex industrial salt solutions may contain small amounts of contaminates in the form of organic materials. Where such complex mixtures exist the rigid vinyls should be tested under operating conditions.

Oxidizing Agents

Rigid vinyl chloride compounds are extremely resistant to oxidizing agents such as strong sulfuric acid, nitric acid, chromic acid, hydrogen peroxide, sodium hypochlorite, and similar materials. The Type I rigid vinyl compound is the most resistant organic material available for such oxidizing media.

Solvents

All rigid vinyl compounds are softened, if not actually dissolved, by organic solvents such as ketones, esters, ethers, and chlorinated and aromatic hydrocarbons. They are inert to such materials as alcohols and aliphatic hydrocarbons.

Oils and Greases

Rigid vinyl compounds are resistant to all common mineral oils and greases. They are resistant as well to cold animal and vegetable oils. In these materials at the liquid level extended exposures at elevated temperatures may cause the rigid vinyl to soften.

Temperature Resistance

Rigid vinyl structures are not recommended for use above 150 F.

Flammability

Rigid polyvinyl chloride will not support combustion and is self-extinguishing.

Fabrication of Rigid Polyvinyl Chloride

In general rigid polyvinyl chloride may be fabricated by extrusion, calendering, finishing, joining and by various types of molding and machining. Sheets and plates up to one-inch thickness, and tubes, pipes, rods and bars of all sizes of rigid polyvinyl chloride are available for fabricating finished articles.

Machining Methods

Machining of rigid vinyls can be accomplished with present practices. Methods used to best advantage are those required for light metals. The most important point to remember is to provide for efficient heat removal from the tip of the cutting or drilling tool. This prevents breakdown of the polyvinyl chloride and the resulting liberation of hydrogen chloride. A coolant is recommended in most machining operations.

In addition to machining, rigid vinyls can be drilled, sawed, and fabricated without difficulty with all types of hand and machine tools. Finishing of edges can be effected by woodworking planes and routers, as well as by belt and disc sanders.

Molding Techniques

1. Draw Forming. One of the most valuable properties of rigid polyvinyl chloride is that it can be formed at temperatures between 260 F and 300 F. Between these temperatures the rigid vinyl becomes soft. Sheets, plates, tubes, and pipes can be bent, curved, and formed by other methods without difficulty. This molding technique usually is referred to as "draw-forming." It can be accomplished by several methods. Use of a male and female mold, as in compression molding, is one method. The hot sheet of rigid vinyl is placed between the male and female mold and with slight pressure is drawn into the shape required.

Another method is manual-stretch-forming. The hot sheet is clamped at one side of a male form, pulled taut by hand over the rest of the form, and held by a clamp until cooled. Vacuum or air pressure forming is the method most often used in "draw-forming." The sheet is generally clamped, heated by a radiant heating element, and sucked by vacuum or forced by air pressure into a female or over a male mold.

Draw-forming methods provide an excellent means of fabricating rigid vinyl sheets. One precaution must be observed. The articles formed by these methods will have "memory." Stresses created in the material during forming tend to return the various sections to their original shape if reheated to the critical temperature. Formed parts must be kept rigidly clamped until they have cooled sufficiently to retain their shape.

2. Injection Molding. Flow properties of rigid polyvinyl chloride resins make them difficult to mold by injection methods. The Type III compound, however, can be injection molded into excellent pipe fittings such as T's, L's, couplings, etc.

Joining Techniques

In general the methods used for joining metals and wood can be adapted to joining rigid vinyls. Bolting, welding, riveting and cementing are a few of the methods which can be used. If required, screwed or bolted joints can be made. There is one precaution to follow in design of joints: Serious consideration should be given to the type threads used and to whether or not the joint should be supported with steel for added strength.

1. Welding Methods.

Unplasticised polyvinyl chloride does not have a melting point. It begins to soften at 170 F and becomes progressively more fluid until it begins to flow at about 360 F. The latter temperature, with a small amount of pressure, a homogeneous bond (weld) can be made between sections of rigid vinyls. One method, the most important for producing this weld, is the hot gas technique.

The principle of the hot gas welding method is similar to that of oxyacetylene welding of metals. The torch used is of the hot gas or "flameless" type. The

filler rod should be of similar composition to the sections of rigid vinyl being welded. The torch may be heated electrically or by a gas flame. The temperature of the stream of hot gas or air may be regulated by varying the heating unit temperature. In any case, the temperature at the orifice of the torch should be between 400 and 600 F for proper welding. The filler rod is placed into the joint to be welded so the hot gas stream will simultaneously heat the rod and sections of rigid vinyl. Multilayer welds for materials thicker than 5/32 inch can easily be accomplished by the hot gas welding process.

2. Cementing

Unplasticized polyvinyl chloride can be cemented without difficulty. This joining method is generally most important when thin sheeting, foils and tubing are being considered. Rigid vinyl piping can be laid with cement joints. The cement to be used ordinarily is made of the rigid vinyl material being jointed dissolved in appropriate solvents. Solvents used successfully in the past are cyclohexanone and tetrahydrofuran. A cement of approximately 12 percent total solids can be made using these solvents.

Sometimes it is advantageous to cement in combination with hot gas welding. This has been practiced in some piping joints. It has been reported that welding and cementing compliment each other to achieve completely pressure-tight fits.

Publication 56-5

Report on Epoxy Resins

A Report of NACE Technical Unit Committee T-6A on Organic Coatings and Linings for Resistance to Chemical Corrosion*

Abstract

Baked epoxy resin finishes yield coatings which give maximum resistance to alkalies, solvents, most acids and general chemical fumes. With the air-dried system in which the epoxy resin is reacted with oil fatty acids to form an ester, the coatings have limited solvent and chemical resistance. The resistance to corrosion, however, is good. With the air-dried system in which the basic epoxy resin is dissolved in suitable solvents and blended with an amine, the coating does not develop full chemical resistance for several days. After this time it shows generally good resistance to chemical fumes, alkalies, acids and salt solutions.

Recommendations are made regarding the use of epoxy resins in various media. Corrosives in which tests were made include three concentrations of sulfuric acid, three concentrations of hydrochloric acid, two concentrations of nitric acid, two concentrations of phosphoric acid, glacial acetic acid, water, two concentrations of sodium hydroxide, ammonium hydroxide, oxidizing agents, three fats and oils, three gases, aldehydes, amines, eight solvents, five salts, and four miscellaneous materials. Epoxy phenolic baked coatings, epoxy amine cured coatings and epoxy ester coatings are considered separately in connection with recommendations for use in the above media.

Application of epoxy resin coatings is considered briefly. Topics discussed include coverages, surface preparation, primers and application methods. Physical properties of epoxy resins are outlined briefly.

Foreword

COMMITTEE T-6A was organized for the purpose of assembling and disseminating to the corrosion engineer, factual and quantitative data on the performance and limitations of the various organic materials that are successfully used in coatings and linings. While every attempt is made to be factual in the coverage of application and chemical resistance tables and physical properties, it nevertheless should be recognized that changes in compounding formulations of organic materials for coatings or linings enhance or detract from their inherent corrosion resistance characteristics. Under such circumstances, these reports and recommendation lists must be viewed as showing average properties only. The possibility of changes in chemical and physical characteristics as produced by various manufacturers or applicators of the material should be kept in mind.

Definitions

Epoxy resins are a class of condensation polymer formed by the reaction of bisphenol with epichlorohydrin. The reaction forms a linear polymer with two reactive groups, hydroxyl and epoxide. The only chain linkage in this polymer other than carbon-to-carbon is an ether linkage. This accounts for the high order of chemical resistance of these resins. Because the phenolic hydroxyl group has been etherified, these resins exhibit generally good color and color retention. Epoxy resins form good continuous films and therefore are suitable for use as protective coatings.

Summary of Properties

Through the hydroxyl and epoxide groups of the epoxy resin molecule, a wide range of reactions is possible with materials such as amino resins, phenolic resins, polyamide resins, vegetable oil fatty acids, or polyfunctional amines. Through use of the above reactive materials as "curing agents," coatings may be obtained which give various degrees of chemical resistance and corrosion protection. These coatings are crosslinked or thermoset and, therefore, lend themselves to use in applications at temperatures where the thermoplastic type of coating would not be suitable. Because of the carbon-to-carbon or ether linkages within the epoxy resin molecule, these resins are extremely stable to the action of alkali and have reasonable resistance to most acids. The degree of resistance is determined by the type and amount of "curing agent" used. To distinguish between baked and air-dried type of epoxy resin coating finishes, these generalizations may be drawn:

1. Baked type finish: epoxy resin cured or crosslinked with phenolic or amino resins; yields coatings which give maximum resistance to alkalies, solvents, most acids, and general chemical fumes.
2. There are two types of air-dry systems:
   (a) A system in which the epoxy resin is reacted with oil fatty acids to form an ester.
   (b) A system in which the epoxy resin is "cured" from a solvent solution with polyfunctional amines.

* R. McFarland, Jr., Hills-McCanna Co., Chicago, Illinois, chairman.

The esters (a), because of their linkage, have limited solvent and chemical resistance. Their resistance to corrosion has been found to be good. In long oil lengths, they may be used on surfaces that are not so meticulously clean. The short oil length esters may be cured with amino resins in baking finishes to give improved chemical resistance, adhesion, flexibility, and impact resistance.

In the second type of air-dry finish the basic epoxy resin is dissolved in suitable solvents and blended with an amine, such as diethylene triamine, at time of use. The initial drying stages of this coating are, therefore, solvent evaporation. In a matter of hours a hard chemical resistant coating is formed. Full chemical resistance is not obtained, however, for several days. This coating has generally good resistance to chemical fumes, alkalies, acids, and salt solutions. The coating cures completely by polymerization (except for the solvent evaporation). Because of this the amine catalyst must be packaged in a separate container and mixed at time of use. Once mixed, the "pot life" of the mixture is limited.

Forms Available

Epoxy resins with a wide range of physical properties are available. Melting points range from less than 8 C to as much as 155 C, with the resins most generally used in corrosion resistant coatings having melting points ranging from 40 C to 155 C. Epoxy resin coatings may be applied by any of the conventional application methods. These include dip, spray, brush, roller coat, or knifing; with this variety of methods available it is possible to get a good range of film thickness. It is a good practice to apply a minimum of seven mils in multiple coats for best chemical resistance where the material is continuously exposed to highly-corrosive media such as acid or alkali atmospheres.

Effect of Compounding

Epoxy resins in the form of cold-cut solvent solutions, or as esters in solvent solutions, may be pigmented with nearly all common pigments by any of the conventional methods. Epoxy resin coatings require careful formulation to develop flexibility, adhesion, and stability.

Resistances

Water and Moisture

Physical and chemical properties of epoxy resins are given in Tables 1 and 2, respectively. Resistance of epoxy resin coatings to water and moisture is not outstanding. In amine-cured epoxy coatings the water absorption amounts to approximately 0.66 percent by weight after 24 hours in water at room temperature. Long-time immersion shows no significant increase over this figure. The moisture vapor transmission at 10 mils thickness is aproximately 2 grams/100 square inches/24 hours at 95 F and pressure differential of 42 mm of mercury. This is low for a paint film but high compared to most chemical resistant coatings. The epoxy resin-amine cured coatings have been evaluated in practical service. Where properly formulated both the epoxy resin ester and epoxy resin-amine cured system were found to possess excellent corrosion resistance.

TABLE 1—Physical Properties of Epoxy Resins

Thermoplastic (TP) or Thermosetting (TS)	TS
Water Absorption	0.66 percent by weight in 24 hours.
Weathering	Good—chalks rapidly but maintains film integrity
Odor	None
Dielectric strength, volts/mil at 60 cycles.	400
Resistance to moisture vapor transmission	Two grams/100 square inches/24 hours/10 mils thick at 95 F and 42 mm mercury pressure differential

Inorganic Acids

Epoxy resin coatings have been found to have good

TABLE 2—Chemical Properties of Epoxy Resins[1]

CORROSIVE	Epoxy Phenolic Baked Coating	Epoxy Amine Cured Coating	Epoxy Ester Coating (Not recommended for immersion
Acids:			
Sulfuric, 10%	R	R	LR
50%	LR	LR	NR
78% +	NR	NR	NR
Hydrochloric, 10%	R	R	LR
20%	LR	LR	LR
35%	NR	NR	NR
Nitric, 10%	LR	NR	NR
20% +	NR	NR	NR
Phosphoric, 10%	R	R	R
85%	LR	LR	NR
Acetic, Glacial	NR	NR	NR
Fatty Acids	R	R	R
Water:			
Tap	R	R	R
Distilled	R	R	R
Sea	R	R	R
Alkalies:			
Sodium Hydroxide, 20%	R	R	NR
70%	R	R	NR
Ammonium Hydroxide, 10%	R	LR	LR
Oxidizing Agents	NR	NR	NR
Fats and Oils:			
Mineral	R	R	R
Animal	R	R	R
Vegetable	R	R	R
Gases:			
Chlorine (wet)	LR	LR	LR
Ammonia	LR	LR	R
Carbon Dioxide	R	R	R
Aldehydes	LR	LR	NR
Amines	LR	LR	NR
Solvents:			
Alcohol Ethyl and Above	R	R	LR
Aliphatic Hydrocarbons	R	R	R
Aromatic Hydrocarbons	R	R	LR
Ketones	LR	LR	NR
Ethers	LR	LR	NR
Esters	LR	LR	NR
Chlorinated Hydrocarbons (General)	LR	LR	NR
Carbon Tetrachloride	R	R	LR
Diethyl Ether	R	R	NR
Salts:			
Sodium Chloride	R	R	R
Sodium Phosphate	R	R	R
Copper Sulfate	R	R	R
Ferric Chloride	R	R	R
Wetting Agents (Ionic and Non-ionic)	R	R	R
Miscellaneous:			
Hydrogen Peroxide, 30%	NR	NR	NR
Sodium Hypochlorite	NR	NR	NR
Chromic Acid	NR	NR	NR
Perchloric Acid	NR	NR	NR

[1] **Code is as follows:** R—Recommended; NR—Not Recommended; LR—Limited Recommendation.

resistance to most inorganic non-oxidizing acids; however, concentration and temperature are the limiting factors so that under certain circumstances a trial under proposed service conditions should be made. Generally, if the coating is to be subjected to continuous exposure, coatings 7 mils thick or better are recommended. On the exterior of equipment and structures subject to spillage or acidic atmospheres, the epoxy resin coatings have shown good durability. Almost all formulations of baked, or amine-catalyzed epoxy resin coatings will withstand non-oxidizing mineral acids and many organic acids at room temperature. They are not resistant to sulfuric acid above 60 percent nor to nitric acid above 10 percent.

Oxidizing Conditions

The epoxy resins are not generally recommended for severe oxidizing conditions such as concentrated sulfuric acid, nitric acid, chromic acid, hydrogen peroxide or sodium hypochlorite solutions.

Organic Acids

Organic acids of the formic and acetic type are exceptionally penetrating, and tests should be made in solutions containing these acids before large applications are made. Organic acids of high molecular weight, such as fatty acids, are less of a problem. In general all three types of the epoxy resin coatings are resistant to contact with fatty acids except at high temperatures.

Alkalies

Baked epoxy and amine-cured coatings have, in general, excellent resistance to alkalies. This is true even in long-time continuous immersion in concentrated caustic soda at temperatures in the 200 F range. Excellent resistance to alkaline salts is obtained. The formula of the coating is important inasmuch as all ingredients must be alkali resistant. The epoxy ester coatings are not recommended for caustic exposure.

Salt Solutions

Epoxy resin coatings have shown good resistance to most salt solutions and can be used at temperatures up to 180 F.

Solvents

The epoxy resin baked coatings have unlimited resistance to alcohols, aromatics, aliphatics, and most of the so-called "active" solvents. Low boiling ketones like methyl ethyl ketone or acetone will soften the film on prolonged exposure. Recovery is complete in 15 minutes. The air-dried epoxy resin-amine cured system has very good resistance to aliphatics, alcohols, and aromatic solvents. Its resistance to ketones is good, but more "active" solvents are not recommended for prolonged exposure. This system will stand splash or spillage of active solvents. The resistance of the epoxy ester coatings depends on the fatty acid with which they are modified.

Oils

Epoxy resin coatings, in general, are resistant to all common oils whether mineral, animal, or vegetable. They are unaffected by gasoline, diesel oil, lube oil, or other aliphatic hydrocarbons.

Temperature Limitations

Date are incomplete at this time regarding all the temperature limitations of epoxy resin coatings. Experience has indicated that they are safe for atmospheric corrosion resistance at temperatures in the range of 250 F. For continuous exposure to most corrosive chemicals 150 F is a safe temperature. Where temperature is a factor, tests under service conditions should be made.

Toxicity

Depending on the formulation by the manufacturer, properly cured films of the epoxy resins are non-toxic and suitable for use with food products.

Adhesion and Abrasion Resistance

In general, the epoxy coatings when thoroughly cured have excellent resistance to rubbing and scuffing. Because of this, they are being used in many places as floor coatings. On properly prepared metal surfaces the adhesion of epoxy coatings is good. On properly prepared concrete, adhesion is excellent.

Hardness

The hardness of epoxy resin films are determined by the type and amount of curing agent used. Baked films show a pencil hardness of 9H, whereas the air-dried amine-cured systems shows a pencil hardness of 4H and a Sward hardness of 33.

Weathering and Aging

Epoxy resin coatings generally show good retention of flexibility, impact, and color upon aging. In direct weathering, epoxy resin coatings have been found to be resistant to cracking and checking on both steel and wood. Epoxy resin coatings tend to chalk heavily under severe weathering conditions. This problem is general for epoxy coatings; however, the outdoor durability is not seriously limited under mild weather conditions.

Electrical Properties

Epoxy resins have been used as printed circuit and wire coatings because of their high insulating strength. Epoxy resins have a dielectric strength of 400 to 500 volts per mil at 60 cycles and an insulation resistance of greater than 10^{14} ohm-cm.

Application

Epoxy resin coatings are supplied in solvent solutions which, after solvent evaporation, cure by oxidation and polymerization, reaction with heat convertible resins, or by polymerization only. Liquid grades of epoxy resins are available which are used in solvent free systems in specialty coatings or in castings, laminates, and adhesives.

Coverages

Coverage will depend on such factors as vehicle formulation, pigmentation, and pigment loading. It may vary between 50-500 square feet per gallon per coat.

Surface Preparation

For maximum resistance to corrosion or whenever an epoxy resin coating is to be used for immersion purposes, steel surfaces should be thoroughly sand or grit blasted. Under conditions where epoxy resins are used as maintenance coatings, and where conditions are not severe, a sandblasted surface may not be necessary. A clean, dry surface, free of all dirt and grease, rust, and mill scale is essential.

Priming

Primers based on air-dry epoxy ester formulations are available in any of the conventional corrosion inhibitive pigmentations. Usually they are not suitable for immersion conditions.

Application Methods

Epoxy resin coatings may be applied by any of the conventional methods now used including brush, spray, dip, roller coat, flow coat, or knifing. Films may be air-dried, force-dried or baked. The baking schedule depends on the formulation and properties desired.

Publication 56-6

Report on Application Techniques, Physical Properties And Chemical Resistance of Chlorinated Rubber Coatings

A Report of NACE Technical Unit Committee T-6A on
Organic Coatings and Linings for Resistance to Chemical Corrosion*

Abstract

Chlorinated rubber can be formulated into coatings which exhibit excellent resistance to most acids, alkalies, salts, mineral oils, moisture and fungus growth. Resistance to oxidizing agents is generally good but is dependent on temperature and concentration of the oxidizing agents. Chlorinated rubber has excellent electrical properties and is nonflammable.

Recommendations are made regarding the use of chlorinated rubber coatings in various media. Corrosives in which tests were made include eight acids, water, five alkalies, six oxidizing agents, eight salt solutions, eight solvents, three fats and oils, chlorine, bromine, iodine, carbon dioxide, sulfur dioxide, and hydrogen sulfide. Recommendations in these media are made both for a temperature of 120 F and for room temperature (70 F).

Physical properties of chlorinated rubber are given. Application of coatings is discussed in detail with attention given to coverage and shipping data, flammability and toxicity, surface preparation, priming, and application methods. Properties of applied coatings and linings are considered with respect to temperature limitations, impact and abrasion resistance, hardness, aging, toxicity and odor, weight, and electrical properties.

Foreword

COMMITTEE T-6A was organized for the purpose of assembling and disseminating to the corrosion engineer, factual and quantitative data on the performance and limitations of the various organic materials that are successfully used in coatings and linings. While every attempt is made to be factual in the coverage of application and chemical resistance tables and physical properties, it nevertheless should be recognized that changes in compounding formulations of organic materials for coatings or linings enhance or detract from their inherent corrosion resistance characteristics. Under such circumstances, these reports and recommendation lists must be viewed as showing average properties only. The possibility of changes in chemical and physical characteristics as produced by various manufacturers or applicators of the material should be kept in mind.

Definition

Chlorinated rubber is the completely saturated product obtained by reaction of natural rubber with chlorine. The reaction yields a product with an average chlorine content of 67 percent. Chlorinated rubber is available in several viscosity types.

Summary of Properties

Chlorinated rubber is one of the most practical of the film-forming materials which are resistant to acids, alkalies, salts, oxidizing agents, mineral oils, moisture, and fungus growth. As is the case with many other film-formers, useful chlorinated rubber coatings are made by compounding with resins (for adhesion and gloss), plasticizers (for flexibility and toughness), pigments and stabilizers. Chlorinated rubber coatings, properly formulated with any one of a variety of popular petroleum solvents rich in aromatics, can be applied by brush, spray, dip, or roller.

Although many properties of chlorinated rubber coatings are dependent on modifying agents, certain properties are inherent in the base film-former. Chlorinated rubber is thermoplastic; it therefore has temperature limitations. It is soluble to some degree in all classes of commonly used solvents with the exception of alcohols, aliphatic hydrocarbons, and water. Because of its high chlorine content chlorinated rubber is nonflammable.

Chlorinated rubber can be formulated into coatings which exhibit excellent resistance to most acids, alkalies, salts, mineral oils, moisture, and fungus growth. Resistance to oxidizing agents is generally good, but depends on temperature and concentration of the oxidizing agents. The excellent electrical properties of chlorinated rubber, coupled with its chemical resistance and nonflammability, make it a good base for electrical cable coatings. Chlorinated rubber coatings also are useful as stop-off lacquers and for equipment protection in electroplating operations.

Forms Available

Chlorinated rubber coatings designed for corrosion-

*R. McFarland Jr., Hills-McCanna Co., Chicago, Illinois, chairman.

control use are available and generally in use in the following forms:

1. As coatings up to about 10 mils thick applied by brush or spray in multiple coats. These coats dry primarily by solvent evaporation.
2. As trowel-applied or sprayed coatings of heavy consistency mastics of 55 to 85 percent solids. Such mastics can be applied up to ⅛-inch thickness in one coating. Unlimited thicknesses are obtainable by multiple coats.

Coatings applied from solvent solution are in general use in the protection of plant structures and equipment exposed to corrosive fumes and chemicals. Such coatings also are widely used on masonry walls and floors because of their excellent alkali and water resistance.

Mastic coatings are useful under corrosive conditions in cases where a cushion is necessary to protect the substrate from high abrasion and impact. Fire resistant, light-weight mastic coatings are available for use as insulation in automobiles, trucks, railway cars and aircraft. In addition to this they can be used in connection with corrosion protection of plant structures and equipment.

Effect of Compounding

As previously stated, chlorinated rubber must be formulated with resins and plasticizers if useful coatings are to be obtained. Where maximum resistance to acids, alkalies, and other corrosive media is desired, suitable modifying agents should be employed. For maintenance coatings subject to corrosive elements, resins such as the hard chlorinated biphenyls are excellent. Inert plasticizers, such as the liquid chlorinated paraffins or chlorinated biphenyls, should be used. The chlorinated rubber coating is best formulated if all of the modifying components are inert to the corrosive agents to which the coatings will be exposed.

Experience indicates that the general range of composition useful in solvent-applied chemical-resistant maintenance coatings of normal pigment content is as given in Table 1. Unpigmented coatings are not recommended for outdoor exposure because of the tendency of chlorinated rubber to discolor in the presence of sunlight or ultraviolet light. Although pigmented coatings have good resistance to ultraviolet light, they are improved by the use of stabilizers. Proper stabilizers should be incorporated in chlorinated rubber coatings to inhibit the formation of acidic degradation products during long term aging.

Mastic coatings differ from normal solvent-applied coatings in that they contain a relatively high proportion of pigment, especially silicates, and are applied at heavy consistencies.

TABLE 1—Composition of Coatings

Material	Vehicle Solids (Percent by Weight)
Chlorinated Rubber	45–60
Resin	5–20
Plasticizer	25–40

Resistances

Water and Moisture

Physical and chemical properties of chlorinated rubber films are given in Tables 2 and 3, respectively. Chlorinated rubber film absorbs water at the rate of about .27 percent in 24 hours at 80 percent relative humidity. The water vapor transmission is about 1.0 grams per 100 square inches per 24 hours per mil of thickness at 95 F and 100 percent relative humidity gradient. Absorption and transmission values of chlorinated rubber compounded with resins, plasticizers, and pigments will depend on the specific ingredients used, but generally they can be expected to be slightly greater than the above values. Chlorinated rubber is a useful base for deck and hull paints because of its resistance to salt-spray. The material can be used also in marine coatings of the antifouling type. Its rapid-drying properties reduce drydock time.

Inorganic Acids

Chlorinated rubber coatings are easily formulated to be resistant to most of the common inorganic acids at room temperatures. At elevated temperatures (to 140 F) chlorinated rubber coatings are effective barriers to dilute acids even under continuous exposure conditions. Suitability of chlorinated rubber coatings for exposure to concentrated mineral acids depends on the temperature and type of service (continuous or intermittent). A minimum film thickness of 4 to 5 mils is recommended for protection of equipment and structures exposed to acid splash or spillage or acidic atmospheres.

Oxidizing Conditions

Chlorinated rubber coatings have excellent resistance to many oxidizing agents at room temperature. At elevated temperatures, such as 120 F, their resistance is lower. Under such conditions concentrated oxidizing acids, such as sulfuric and nitric, cause deterioration of the coatings. With other strong oxidizing agents chlorinated rubber coatings should be tested under the expected service conditions to verify their suitability.

Organic Acids

The lower aliphatic acids, such as acetic acid, cause

TABLE 2—Physical Properties of Chlorinated Rubber

Thermoplastics (TP) or Thermosetting (TS)	TP
Water absorption[1] of free film, percent at 80 percent relative humidity in 24 hours	0.27
Water vapor transfer[1] of free film, grams/100 square inches/mil in 24 hours at 95 F and 100% relative humidity	1.0
Maximum safe temperature for continuous coatings exposure under:	
Dry conditions	225–250 F.
Wet conditions	140 F.
Weathering (pigmented coatings)	Excellent
Odor	None
Flammability	Nonflammable
Dielectric strength[1] of free film, volts per mil	2,300

[1] Unmodified chlorinated rubber.

degradation of chlorinated rubber coatings unless such acids are at concentrations of 10 percent or less at, or below, room temperature. Although they are not resistant to fatty acids, chlorinated rubber coatings afford good protection against food acids (such as citric acid). In general, it is best to test the coating by exposure under service conditions.

Alkalies

Chlorinated rubber can be formulated into coatings with good resistance to all of the common alkalies with the exception of concentrated ammonium hydroxide or dilute ammonium hydroxide above room temperature.

Chlorinated rubber is especially useful in formulating coatings for all types of masonry (including concrete floors) because of its resistance to alkalies and moisture. It also is useful in finishes for dairy and bottling plants where many other types of finishes are attacked by spillage of strong washing solutions.

Salt Solutions

Coatings with a chlorinated rubber base have excellent resistance to all types of salt solutions. Ionizable salts of acids which degrade chlorinated rubber coatings do not cause bad effects because only a very low acid concentration is obtained by hydrolysis of the salt.

Solvents

Chlorinated rubber is softened or dissolved by nearly all classes of the common solvents with the exception of alcohols, aliphatic hydrocarbons, and water. Consequently, chlorinated rubber coatings cannot be expected to have generally good resistance to solvents. When selecting a chlorinated rubber coating for protection against the three latter types of solvents, tests should be run to ensure that all the coating components are resistant to these solvents.

Fats and Oils

Chlorinated rubber coatings have excellent resistance to mineral oils. Chlorinated rubber is sensitive to fats and oils of animal or vegetable origin, but it is possible to formulate coatings resistant to vegetable oils by modification with amine-aldehyde resins.

Properties of Applied Coatings and Linings

Temperature Limitations

The temperature limitations of chlorinated rubber coatings depend to a large degree on the resins, plasticizers, pigments, and stabilizers used in compounding the coating. A typical coating formulated for maximum chemical resistance (contains chlorinated resins and plasticizers as sole modifying objects) shows no tendency to flow at temperatures up to 300 F. At temperatures approaching 300 F degradation occurs rapidly unless appropriate heat stabilizers are incorporated.

Normally it is recommended that chlorinated rubber coatings not be subjected to continuous dry heat at temperatures above 225 F to 250 F. Safe maximum wet temperature is about 140 F. There are numerous commercial installations, however, where chlorinated rubber coatings are giving satisfactory service at temperatures of 180-200 F in moist atmospheres. For intermittent service, the above limits can be exceeded. It is recommended that individual coating formulations be tested for suitability before subjecting them to continuous exposure at temperatures in excess of 140 F.

With decreasing temperature, chlorinated rubber coatings increase in hardness and brittleness. Normal formulations afford good general protection down to —10 F and special formulations can be made which will withstand even lower temperatures.

TABLE 3—Chemical Properties of Chlorinated Rubber Coatings[1, 2]

Corrosive Medium	Resistance	
	Room Temp. (70 F)	120 F
Acids:		
Sulfuric, 10%	R	R
Sulfuric, Concentrated	R	NR
Hydrochloric, 10%	R	R
Hydrochloric, Concentrated	R	NR
Nitric, 10%	R	R
Nitric, Concentrated	NR	NR
Phosphoric, 10%	R	R
Phosphoric, Concentrated	LR	NR
Hydrofluoric, 10%	R	R
Hydrofluoric, 30%	R	R
Lower Fatty, e.g., Acetic, 20%	R	NR
Lower Fatty, e.g., Acetic, Concentrated	NR	NR
Higher Fatty, e.g., Oleic	NR	NR
Organic Food, e.g., Citric	R	R
Water:		
Tap	R	R
Distilled	R	R
Sea	R	R
Alkalies:		
Sodium Hydroxide, Dilute	R	R
Sodium Hydroxide, Concentrated	R	R
Calcium Hydroxide	R	R
Ammonium Hydroxide, Dilute	R	NR
Ammonium Hydroxide, Concentrated	NR	NR
Ammonium Salts	R	LR
Sodium Carbonate	R	R
Oxidizing Agents:		
Hydrogen Peroxide, 30%	R	NR
Sodium Hypochlorite	LR	LR
Calcium Hypochlorite	R	R
Chromic Acid, 40%	LR	NR
Chromic Acid, 5%	R	R
Sulfur Dioxide Solutions	NR	NR
Chlorine Water	R	R
Salt Solutions:		
Alum	R	R
Ferrous Sulfate	R	NR
Copper Sulfate	R	R
Sodium Chloride	R	R
Calcium Chloride	R	R
Sodium Sulfate	R	R
Sodium Phosphate	R	R
Sodium Acetate	R	R
Solvents:		
Chlorinated Hydrocarbons	NR	NR
Aromatic Hydrocarbons	NR	NR
Aliphatic Hydrocarbons	LR	LR
Alcohol (methyl, ethyl & butyl)	LR	LR
Ethers	NR	NR
Esters	NR	NR
Ketones	NR	NR
Phenol	NR	NR
Fats and Oils:		
Mineral	R	R
Animal	NR	NR
Vegetable	NR	NR
Halogens (Moist):		
Chlorine	R	R
Bromine	NR	NR
Iodine	R	R
Gases (Moist):		
Carbon Dioxide	R	R
Sulfur Dioxide	R	—
Chlorine	R	R
Hydrogen Sulfide	R	—

[1] Code is as Follows: R—Recommended; NR—Not Recommended; LR—Limited Recommendation (See Notes.)
[2] Type of formulation definitely affects chemical resistance.

Impact and Abrasion Resistance

Although chlorinated rubber does not retain the flexibility and elasticity of natural rubber, coatings based on chlorinated rubber have fair to good impact resistance in comparison to other coatings. Abrasion resistance, under wet or dry conditions, also is fair to good but depends on the specific formulation. Under conditions where the coating is likely to be subjected to high impact and abrasion the use of chlorinated rubber mastics should be investigated. Mastics can easily be applied to achieve a thick coating (up to ⅛-inch in one application) which will afford a better cushion than the relatively thin films applied from solution.

Hardness

Films of unmodified chlorinated rubber have Sward hardness values of about 70-80. Formulated coatings, depending on their exact composition, have Sward hardness values of 20-50.

Aging

Properly pigmented chlorinated rubber coatings have consistently exhibited good protection in atmospheric conditions. Some pigments, such as red lead, have a stabilizing action on chlorinated rubber. Inert pigments, such as iron and titanium oxides, require added stabilizer to resist the effects of acidity which can form in chlorinated rubber coatings during long exposures. Epoxy-type stabilizers are especially useful.

Clear chlorinated rubber coatings are stable indoors at room temperature and in the absence of ultraviolet light. Addition of an epoxy stabilizer imparts good heat stability, but sunlight or other ultraviolet light sources can still cause relatively rapid discoloration.

Toxicity and Odor

Chlorinated rubber is odorless, tasteless and nontoxic. Depending on the choice of pigments, vehicle modifiers, and stabilizers used, nontoxic coatings are available for use in contact with food and potable water.

Weight of Applied Coatings

Depending upon the exact formulation, weight per square foot per 5-mil thickness varies from 0.042 to 0.15 pound. Mastic coatings, because of their high pigment volume, will vary considerably in weight depending on the specific gravities of the pigments used. Representative mastic coatings weight approximately 1.5 pounds per square foot per ⅛-inch thickness.

Electrical Properties

Clear unplasticized chlorinated rubber film has a dielectric strength of 2,300 volts per mil. Specific surface resistance of such film is $2{,}000 \times 10^{-10}$ ohms. As noted previously, the excellent electrical properties of chlorinated rubber coupled with its chemical resistance and nonflammability make it an excellent base for cable coatings and stop-off lacquers. It can be used also for equipment protection in electroplating operations.

Application

Chlorinated rubber coatings are supplied as solutions in volatile solvents or as heavy consistency mastics.

Coverage and Shipping Data

Clear and black chlorinated rubber coatings have specific gravities of 0.9 to 1.15. White and other pigmented coatings range from 1.08 to 1.9 depending on the concentration and specific gravity of the pigment. Chlorinated rubber mastics are heavily pigmented and have specific gravities of about 1.5 to 2.0. On a pounds per gallon basis, clear and black coatings should weigh about 7.5 to 10 pounds per gallon. White and other pigmented coatings should weigh about 9 to 16 pounds per gallon. Mastics should weigh about 12.5 to 17 pounds per gallon.

Coverage varies considerably depending on the density of resins, plasticizers, and pigments used. Solution coatings range in specific gravity from 0.9 to 1.9 and variations in solids accrue. For this reason coverage varies from 300 to 360 square feet per gallon for a 1.0-mil dry coat. Mastics cover about 40-50 square feet per gallon when applied in a 1/32-inch thickness.

Flammability and Toxicity

Chlorinated rubber coatings, both solution and mastic coatings, are formulated principally with aromatic hydrocarbons. Vapors of such solvents are toxic. Persons applying such coatings in enclosed spaces should wear safety breathing-masks.

Normal formulations for coatings to be applied by brush contain solvent blends whose flash points are above 100 F. Other chlorinated rubber coatings usually contain solvents with a flash point of about 84 F. Special formulations may have a flash point below 81 F. These formulations require a red label.

Surface Preparation

All substrates should be dry and free from grease or oil before a chlorinated rubber coating is applied. New or uncontaminated metal surfaces require no special preparation. If mill scale is present, sand blasting or pickling will increase durability. Corroded metal surfaces should be sandblasted for optimum results, but can be cleaned by wire-brushing or sanding to obtain good coating adhesion. Wood needs no particular preparation.

For long wear, chlorinated rubber-based coatings should be applied to concrete floors and walls only after the surface has been cleaned and etched with 10 percent hydrochloric acid, washed with clear water, and allowed to dry.

Before applying a chlorinated coating over a painted surface, the "lifting" properties should be evaluated by the application of a small area on the old paint.

Priming

Primers based on chlorinated rubber are generally used for chlorinated rubber topcoats. They are also useful as primers under other types of finishing coats such as vinyl co-polymers.

In some cases, chlorinated rubber paints are used over other primers, such as those based on alkyds. This is done to avoid subsequent lifting of the alkyd when a topcoat of the vinyl co-polymer type is applied.

Wash primers made from polyvinyl butyral resin or other primers such as those based on drying oils, alkyds, phenolic dispersion—pigmented with red lead or zinc chromate—are frequently used for chlorinated rubber topcoats.

Application Methods

Solution coatings can be applied by brush, spray, dip, flow, or roller coating. Mastics are generally applied by troweling or by spraying with equipment of the type used for spraying cement mixtures. All types of chlorinated rubber coatings dry primarily by solvent evaporation, but some types, especially those intended for relatively mild chemical exposure, may contain oxidizing oils or alkyd resins. Although baking is not required, optimum corrosion resistance is obtained by force-drying or by allowing sufficient air-dry time between coats to facilitate solvent removal.

Solution coatings may be applied to any desired thickness by multiple coats. A minimum of 5 mils is recommended for chemical exposure. A single brush coat will vary from about 1.0 to 2.0 mils, depending on consistency. A single spray coat usually varies from 0.7 to 1.0 mils. Mastic coatings can be applied in one coat to give thicknesses up to ⅛-inch; greater thicknesses can be obtained by multiple coatings.

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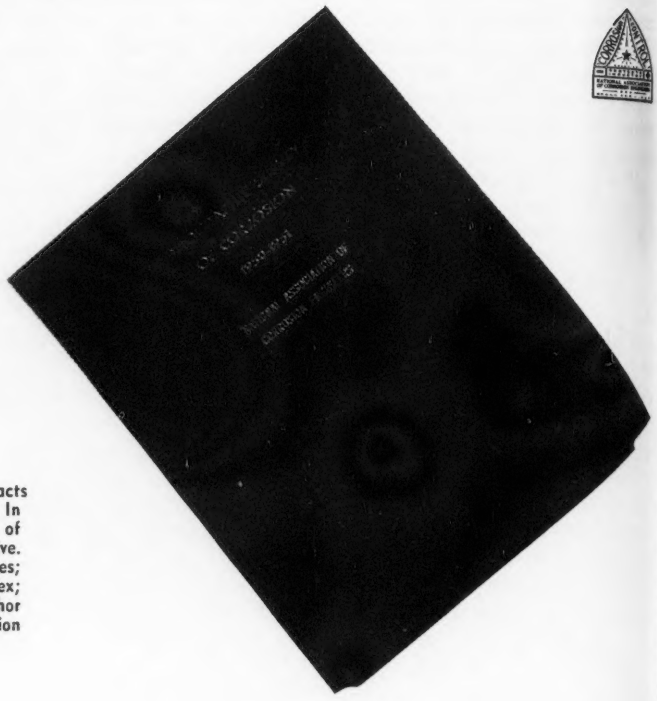

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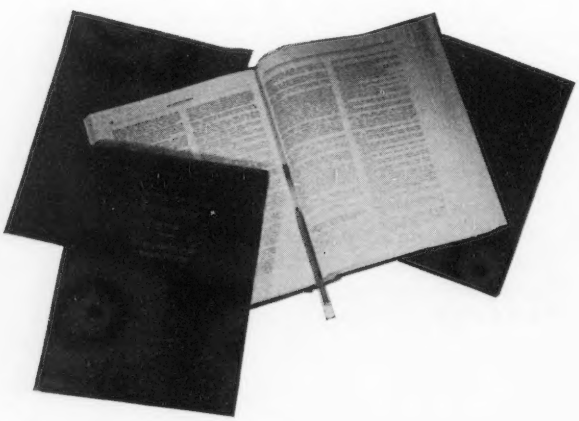

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TECHNICAL COMMITTEE ACTIVITIES

Orderly Arrangement of Pump Materials Considered as Project for T-D Group

Corrosion Test Coupons To Be Ready by April 15

Coupons to be used in the testing program of T-2E on Internal Corrosion of Product Pipe Lines and Tanks will be available from Central Office NACE about April 15, it was reported in New York by Ivy M. Parker, Plantation Pipe Line Co., Atlanta, chairman. The New York session of the committee, attended by 30, was held during the 12th Annual NACE Conference.

Problems associated with inhibitor applications, scraper programs, and internal corrosion of storage tanks were discussed. The committee is considering a new project involving collection of data on tank wall inspection.

Coordination of Corrosion Committees Contemplated

C. P. Larrabee, chairman of the Technical practices Committee reported to the NACE board of directors March 16 that a new technical committee has been added to those organized by NACE. The committee is to be known as T-7 on Cooperative Corrosion Committees.

Mr. Larrabee said the new organization would consist of groups organized only at the section level whose objective would be cooperation in protecting underground metal plant from corrosion. Liaison between sectional organizations, when necessary, would be available at the regional level, Mr. Larrabee said.

ASTM Accepts Revised Questionnaire of T-5

American Society for Testing Materials has accepted T-5E's revision of its questionnaire. The committee, on Stress Corrosion Cracking of Austenitic Stainless Steels, met during the NACE Conference in New York with Ed. V. Kunkel, Celanese Corp., presiding. There were present 22 members and 12 guests.

M. E. Holmberg, Houston, recommended that T-5E accept the revised ASTM questionnaire. Details of distributing the questionnaire by ASTM and NACE are to be decided by the steering committee.

Orderly arrangement of information on pump materials may be considered by a task group of T-1D on Sour Oil Well Corrosion. J. A. Caldwell, Humble Oil and Refining Co., Houston, chairman reported this action after the committee's meeting in New York March 15 during the 1956 NACE conference. Forty-one were present at the meeting.

Discussion on pump corrosion developed a consensus that less progress has been made in reducing damage to pump by the use of inhibitors than by other controls. Also considered during the session were problems related to internal casing corrosion, tanks and inhibitor application.

W. C. Koger, Cities Service Oil Company, presented his paper "Physical Behavior of Corrosion Inhibitors in Well Fluids." Discussion was enthusiastic.

R. E. Lembcke, Cities Service Research and Development Co., Tulsa, has been elected chairman and J. V. Gannon, The Texas Company, Midland, Texas, vice-chairman of the group.

Integration Into NACE of Coatings Groups Weighed

The question of integrating into NACE the numerous coatings committees that have been established for instruction in techniques at the painter's level will be reviewed by the NACE board of directors. The committees, many of which include NACE members as instructors or advisers, have in some instances asked that NACE undertake to sponsor their activities on some basis yet to be determined.

President Fair named as a committee of the board to study the problem H. L. Waldrip, C. G. Munger and C. P. Larrabee. The committee was asked to make recommendations soon to the board.

Payton, Loncaric Elected By Sweet Oil Well Group

Joy T. Payton, The Texas Company, Houston, has been elected chairman and Radio Loncaric, Atlantic Refining Co., Dallas, vice-chairman of T-1C on Sweet Oil Well Corrosion. The elections were announced at the committee's meeting in New York during the 12th annual conference.

SEEN AT TECHNICAL committee meetings in New York: (left) J. A. Caldwell, Humble Oil & Ref. Co., Houston, presides at a T-1D meeting; (center) left, R. C. Buchan, Humble Oil & Ref. Co., Houston and W. H. Edwards, Superior Oil Co., Houston shown at a meeting of T-1B; (right) E. V. Kunkel, Celanese Corp., Bishop, Texas and M. E. Holmberg, consultant, Houston are seen at a meeting of T-5E.

MORE TECHNICAL committee views: (top) T. J. Maitland, American Telephone & Telegraph Co., New York and J. P. Oliver, National Carbon Division, Cleveland, at T-2B meeting; (middle) at T-4D session, D. A. Spalding, Dow Chemical Co., Midland, Mich. and D. W. Kaufman, International Salt Co., Buffalo, N. Y.; (bottom) L. F. Heverly, Buckeye Pipe Line Co., Lima, Ohio and W. E. Huddleston, Huddleston Eng. Co., Bartlesville, Okla. shown at a meeting of T-2D.

More News of TECHNICAL COMMITTEE ACTIVITIES at the New York Conference will be published in May CORROSION

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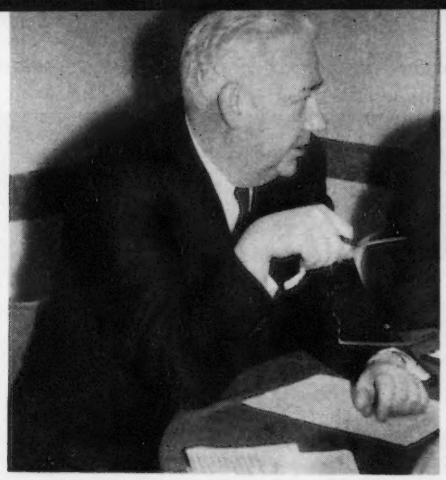

HARD-AT-WORK members of the NACE board —Upper left, W. F. Fair, Jr., president; upper right, W. H. Stewart, vice-president; bottom, F. L. Whitney, Jr., past president confers with George E. Best, Northeast Region director and A. B. Campbell, NACE Executive-secretary.

All Records Broken at New York Conference

Outstanding Technical Program Is Leading Feature of Meeting

An outstanding technical program was conceded to be the feature most often praised by persons attending the 1956 12th Annual Conference and Corrosion Show at New York. Very heavy attendance at symposia and technical committee meetings was the rule. This program, plus the well-rounded schedule of social activities planned by the conference committee resulted in what is believed to be record registration, record attendance and a sell-out of the largest exhibition NACE has yet staged.

Kempton H. Roll, Lead Industries Association, New York, and his committeemen were praised for their efforts by the NACE officers and board at a meeting March 16. Mr. Roll reported that paid regular registration was 1829, 163 ladies registered, 863 registered for exhibition only and 612 banquet tickets were sold. On the basis of these figures it is believed the 12th annual conference may be a record breaker in several categories of attendance.

Income Is Better

Preliminary estimates indicated that the net return from the conference to the association would be larger than early budgets showed. Expenses were apparently in balance with the budget, although complete records were unavailable when Mr. Roll made his report to the NACE board March 16.

The financial status of the conference was better than anticipated largely as a result of the fact that the Corrosion Show was sold out. Increased registration income also was a factor.

Friend Is Praised

W. Z. Friend, The International Nickel Co., Inc., New York, chairman of the Technical Program Committee was personally praised by many for the quality of the technical program. Besides being the most extensive ever given at an NACE national meeting, the quality of the papers presented was reported to be very high. The technical program was considered to be the outstanding accomplishment of the conference.

A canvass of attitudes among exhibitors is under way to establish the good and bad points of the 1956 show. Results of this survey will be compiled to guide the exhibit chairman for the St. Louis 1957 conference. Mr. Roll reported that preliminary information from exhibitors was generally favorable.

Ladies Are Active

Bad weather, including rain, snow and sleet failed to hamper the activities of the ladies' group. Arrangements by Mrs. Beatrice Bailey, Consolidated Edison Co. of New York, chairman of the ladies program committee worked smoothly. Attendance by ladies was slightly in excess of the maximum number contemplated in early estimates.

Executive Committee May Meet Oftener, Fair Says

The NACE executive committee, consisting in 1956-57 of W. F. Fair, Jr., president; F. L. Whitney, Jr., past president; W. H. Stewart, vice-president; George E. Best, Northeast Region director and R. A. Brannon, treasurer may meet more often this year. President Fair indicated he believed the association's affairs have grown to the point that the previous schedule of meetings was inadequate.

One benefit expected to accrue from more frequent meetings of the committee, Mr. Fair indicated, would be a reduction of time devoted to board meetings. Agenda for board meetings often are so extensive that they are not covered in full, Mr. Fair said.

Committeeman Is Named

Dave Thompson, who works in the laboratories of The American Brass Company has been added to the NACE Editorial Review Subcommittee.

AT THE ANNUAL BANQUET—Top, left to right, E. L. Simons, General Electric Research Laboratory, Schenectady, who received the 1955 Award to Young Authors; Mars G. Fontana, Ohio State University, Columbus, who received the 1956 Whitney Award and Norman Hackerman, University of Texas, who received the 1956 Speller Award. Center, Kempton H. Roll, Lead Industries Association, New York, conference general chairman, gives some highlights about the meeting; nearest the camera is R. A. Brannon, Humble Pipe Line Co., Houston, perennial NACE treasurer. Bottom, right, Hugh A. Hamilton, A. V. Smith Engineering Co., Narberth, Pa. chats with F. N. Speller, consultant, Pittsburgh. The Speller award is named after Dr. Speller.

Exhibits at Regional Meetings Are Considered

Holding exhibitions at regional meetings of the National Association of Corrosion Engineers was approved in principle by the NACE board of directors at its meeting March 16 in New York. Details of this policy will be discussed by the association's executive committee before a policy change is presented to the board.

Corrosion is indexed annually by Engineering Index.

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A 10-Year Index to the material in Corrosion Technical Section 1945-54 inclusive will be published soon.

Publicity Effort at N.Y. Is Carefully Executed

Arrangements to inform and assist representatives of the press at the 1956 Conference in New York were carefully planned and executed. These arrangements included a permanent press room, a press conference attended by NACE officers and conference officials and other aids.

Malcolm W. Riley, Materials and Methods magazine, was chairman of the publicity committee.

More Participation By NACE Members Is Urged by Whitney

More participation by NACE members in the technical activities of the association was urged by retiring NACE president Frank L. Whitney, Jr., at the annual business meeting March 16 in New York. Mr. Whitney pointed out that only 20 percent of the members take part in technical committee activities.

Mr. Whitney's remarks were followed by reports from the association's standing committees on the year's activities.

The retiring president also suggested that NACE members make known to advertisers in CORROSION their use of CORROSION advertising. This would benefit the magazine by giving advertisers more confidence that their expenditures were effective among association readers.

Formal Corrosion Education

Mr. Whitney also urged the association to consider the implications of a recent survey among 141 major colleges in the United States which revealed that only 37 offer specific course in corrosion and that only 550 students were taking the courses.

H. C. Van Nouhuys, Southeastern Pipe Line Co., Atlanta, chairman of the Regional Management Committee reported the addition of four sections by NACE during the year, two in the Southeast Region and one each in the Northeast and North Central Regions. He also pointed to seven regional meetings with attendance of 2000 and over 400 meetings of local sections with an estimated total attendance of 14,000.

Nine Short Courses Held

Norman Hackerman, University of Texas, chairman of the Committee on Education, listed nine short courses held during the year with NACE cooperation, or wholly given by NACE. He also cited courses abroad as indicative of the increased interest in and value of short courses.

Among coming short courses known to the committee is one at Ohio State University scheduled for September and a general short course in the Pacific Northwest early in 1957.

O. W. Wade Is Editor of Planned Corrosion Manual

O. W. Wade, Transcontinental Gas Pipe Line Corp., Houston, will be the editor of a projected Corrosion Manual on Cathodic Protection to be compiled and published by NACE. F. L. Whitney, Jr., NACE past president and J. E. Loeffler, Thornhill-Craver Co., Houston, who have been considering the publication named Mr. Wade at the March 16 meeting of the NACE board in New York.

Mr. Loeffler acts in liaison between the technical practices committee and the publication committee.

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Indexes to Corrosion's Technical Section, Technical Committee Activities Section and Corrosion Abstract Section are published annually in the December issue.

Decision Is Reached on NACE Publication Policy

T. P. May, chairman of the NACE publication committee advised the board of directors March 16 that his committee had reached agreement on a statement of the association's policy respecting publication of technical papers by journals other than those of the association. This policy, consisting principally of a re-statement of existing policy with no major changes, will be prepared for conideration by the board.

Dr. May recommended, however, and the board approved a procedure for extending the information on the association's publication policies. This would include a special letter to membership, publication in CORROSION, inclusion in programs prepared for NACE meetings and in the NACE Guide for Preparation and Presentation of Papers. Dr. May also recommended that pre-prints of technical papers prepared for presentation at NACE meetings should include this statement of policy on face-sheets.

Members to Be Surveyed On Yearbook Publication

Members of NACE will be asked in the near future whether or not they want to purchase a copy of the NACE Yearbook for 1956. In a policy change approved by the NACE board of directors at its meeting in New York Friday, March 16 it was decided that the yearbook would be published for sale to NACE members and not distributed free of cost as has been the practice since the association was organized.

Because the association has budgeted a deficit for 1956, the board agreed that the association should undertake the publication of the 1956 yearbook for sale at $1.50 a copy, with the aim of making it self-supporting.

Classified Industrial Directory Set for 1957

Approving a recommendation of the NACE Publication Committee, the NACE board of directors has instructed Central Office to conduct a survey to determine the extent of interest in and the potential advertising revenue that can be expected from the publication of a classified industrial directory of firms active in the corrosion field. The mail survey will be made soon among NACE members and others likely to be interested in the project.

The directory, if published, will be included as a part of the NACE Yearbook.

Kunkel Is New Editorial Review Committee Head

E. V. Kunkel, Celanese Corp., Bishop, Texas has been named chairman of the NACE Editorial Review Subcommittee. He succeeds A. W. Tracy, chairman in 1955-56, a long time member of the committee.

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Technical material published in Corrosion is abstracted in the biennial Bibliographic Surveys of Corrosion published by NACE.

Hackerman's Response on Receiving Whitney Award

Following is the response of Norman Hackerman, University of Oklahoma, Austin on receiving the 1956 Whitney Award at New York:

Dr. Wachter, Ladies and Gentlemen:

On behalf of my laboratory I am indeed very pleased to accept the 1956 Whitney Award. My students and I certainly appreciate knowing that the researches with which we have been occupied over the past ten or so years appear to have some significance. The absolute extension of knowledge gained in any paper or papers usually does not lend itself to ready evaluation. However, if the papers prove stimulating in any way the effort will have been well spent and the effect will be gratifying to those who were involved. In fact, this benefit alone is sufficient justification for the need for maintaining and strengthening the so-called academic research activities in all fields of engineering and science. In other words, the principal gain from basic research may not necessarily be the new facts that it uncovers, or even the new principles to which it may lead, but in the activation of men's minds. It appears to me that this thought must have been one of the main bases upon which the Whitney award was established. Whether or not this is exact is probably open to question but the concept of recognizing purely scientific work in an area which is primarily concerned with engineering developments is certainly a very important one. I am indeed proud that you saw fit to accord my laboratory such a signal honor.

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Scenes at the Corrosion Show, Hotel Statler, New York, March 12-16, 1956

SERVING AT THE LADIES' coffee hour during the 1956 NACE Conference at New York were (top) Mrs. F. J. LeFebvre and (center) Mrs. F. J. Law. Mrs. Beatrice Bailey (bottom), Consolidated Edison Co., was ladies' committee chairwoman. A full week of entertainment was enjoyed.

Miss Bebbington Resigns

Miss Marguerite Bebbington, The International Nickel Co., Inc., New York, for several years chairman of the Abstract Subcommittee of the NACE Publication Committee has resigned.

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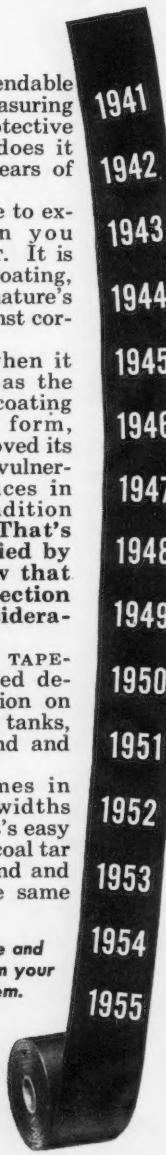

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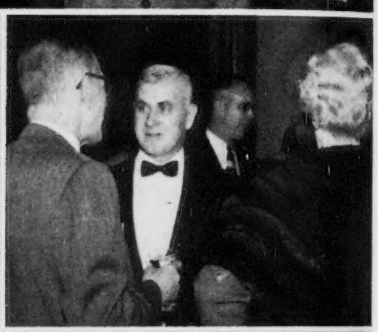

SOME OF THE GUESTS at the Fellowship Hour at the NACE 12th Annual Conference in New York: Top, left to right, Clarence Hervey; S. K. Coburn, Association of American Railroads; Norman Hackerman, University of Texas and J. J. Harwood, Office of Naval Research; Center: top left, Robert D. Misch, Argonne National Laboratories and Miss Antoinette Guerino; top right, F. L. LaQue, The International Nickel Co., Inc.; center bottom left, Mr. and Mrs. Joe F. Tatum, Willmut Gas and Oil Co.; bottom right, E. D. Verink, Aluminum Co. of America; bottom photograph, L. B. Donovan, Consolidated Edison Co. of New York, Don Lachmund, Amercoat Corp.

NACE NEWS

Bradley

Dillon

Fontana

Godard

Lusby

Teeple

Year's Program Is Set by Niagara Falls Section

Programs through April, 1957 have been arranged by Niagara Frontier Section. First scheduled is a March 20 joint meeting with The Electrochemical Society and the American Chemical Society at Prospect House, Niagara Falls. H. H. Uhlig, Massachusetts Institute of Technology, was the scheduled speaker on "Corrosion Inhibitors."

The programs planned are:

May 9-10—Spring Symposium in cooperation with University of Buffalo on Control of Corrosion in the Chemical Industry—Proper Use of Metals and Alloys for Corrosion Prevention.

Oct. 10—Glass in the Chemical Industry.

Nov. 7 or 14—Election of officers and "Coatings" meeting.

January, 1957—Business meeting.

February, 1957—Stress Corrosion.

April, 1957—Corrosion Problems Relating to the Sewage and Water Works.

Murdison Elected Canadian Region Director 1956-59

A. R. Murdison, Imperial Oil Ltd. of Toronto has been elected Director of the Canadian Region to serve a three year term beginning March 16, 1956.

The following were elected officers of the region for 1956: T. R. B. Watson, Corrosion Service Limited, Toronto, Chairman; F. W. Hewes, Canadian Protective Coating Limited, Edmonton, Alberta, Vice-Chairman, and R. E. Kuster, Union Gas Company of Canada, Limited, Chatham, Ontario, Secretary-Treasurer.

Vancouver Holds Program On Zinc Developments

The January 30 meeting of Vancouver Section held in the Devonshire Hotel was attended by 30 members and guests. J. R. Wellington, Consolidated Mining and Smelting Company of Canada, Ltd. spoke on "Recent Developments in Zinc." He discussed three of the most prominent applications of zinc with regard to corrosion: cathodic protection, plating and paints.

More than 500 periodicals are canvassed for abstracts appearing in Corrosion Abstracts.

Roll

Stern

Weisert

Niagara Section's May 9-10 Symposium on Chemical Industry Corrosion Includes LaQue

Niagara Section will hold its May 9-10 symposium on Control of Corrosion in the Chemical Industry on the campus of Buffalo University. Details of the technical program were published in Corrosion, March, on Page 81.

Fees for the meeting are: Registration, $12; luncheon reservations $2 each; banquet reservation $5. Advance registration and arrangements for rooms may be made with Mrs. Ethel E. Schmidt, Director of Special Services, University of Buffalo, 3435 Main St., Buffalo 14, N. Y. Mail advance reservations close May 2, 1956.

Frank L. LaQue, The International Nickel Co., Inc., New York will act as moderator during part of the program.

Authors of technical papers to be presented include:

W. W. BRADLEY—Bell Telephone Laboratories. William W. Bradley received a M.S. degree in chemical engineering in 1949 from the University of Colorado. Since that time, he has been associated with the Bell Telephone Laboratories where he is concerned with problems involving corrosion and its mitigation. He is co-author with R. M. Burns of "Protective Coatings for Metals" and the author of several papers on galvanic corrosion and metallic coatings. Mr. Bradley is a member of the Electrochemical Society, AAAS, ASTM and the ASM committee on electroplated coatings.

C. P. DILLON—Carbide and Carbon Chemicals Company. C. P. Dillon was educated at Fordham and Georgetown Universities, receiving a BS degree in chemistry in 1942. Since 1950, he has been group leader of the Corrosion and Metallurgical Group at the Texas City plant of the Carbide and Chemicals Company. In addition to publishing papers on chemical process corrosion, cooling water corrosion and tanker corrosion, Mr. Dillon has presented sessions at regional conferences and short courses on corrosion. He is a member of ACS, ASM and NACE and is active on several technical practice committees of NACE.

MARS G. FONTANA—Professor of metallurgical engineering and metallurgical research at Ohio State University, Dr. Fontana is well acquainted with corrosion problems besetting the chemical industry. His work covers two years on high temperature-pressure research, 11 years as metallurgical engineer with DuPont, Editor of "Corrosion Forum," (I and EC), consultant for DuPont, Duriron Co. and others and he has published technical material in "Corrosion" as author and co-author.

He holds a BS degree in ChE (1931), MS in Metallurgical Engineering (1932) and PhD in Metallurgy (1934) at the University of Michigan and Speller Award (1956).

HUGH P. GODARD—Head of the chemical division, Aluminium Laboratories, Ltd., Dr. Godard has been occupied for the past ten years with the corrosion behavior of aluminium. His background as industrial chemist in explosives, wood pulp, copper and gold mining have contributed toward his appreciation of the cost of corrosion to the chemical industry. He has published several papers on the corrosion behavior of aluminum and its alloys.

He holds a PhD in Industrial and Cellulose Chemistry from McGill University and Masters degree in chemical engineering from the University of British Columbia.

S. H. KALIN—U. S. Steel Corporation. S. H. Kalin received a BS degree in Metallurgy from MIT in 1938 and is at present Research Technologist in the Chemical Metallurgy Division of the Applied Research Laboratory, U. S. Steel Corporation. For the past four years he has been engaged in the investigation of intergranular corrosion and stress corrosion of stainless steel, the evaluation of various steels in specific corrodents and studies of atmospheric corrosion of steels and metallic coatings. He is a member of NACE and the ASTM subcommittee on stainless steel in architectural applications.

WILLIAM E. LUSBY, JR.—Dr. Lusby's work includes corrosion research on titanium and

(Continued on Page 70)

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Double Afternoon Sessions Set at Oklahoma University Corrosion Control Course April 3-5

Double afternoon sessions will be held during the April 3-5 Corrosion Control Short Course at Norman, Okla. The course, sponsored by University of Oklahome and Central Oklahoma Section NACE, will have two simultaneous sessions on each of the three afternoons to accommodate the lengthy and diverse program.

While principal interest will be centered on underground problems, sessions have been scheduled also on plants and refineries, economics and management problems, instruments, petroleum production and a general section. Inhibitors for oil wells and cooling water systems will be discussed.

The program scheduled for the event is as follows:

Tuesday, April 3

Morning:

Welcome, Wm. H. Carson, Dean of Engineering, University of Oklahoma.
Review of Recent Developments in Corrosion Control, Jack Barrett, Stanolind Oil and Gas Co.
Theory of Corrosion Inhibitors, Parke D. Muir, Dowell, Inc.
Theory of Cathodic Protection, Yale W. Titterington, Corrosion Engineer, Corrosion Services Inc.

Afternoon: Pipelines Section

Use of Rectifiers in Corrosion Control Work, Ray M. Wainwright, Electrical-Mechanical Div., Goodall Mfg. Co.
Using Sacrificial Anodes for Protecting Pipelines Against Corrosion, J. N. Hunter, Jr., Service Pipe Line Co.
Rectifiers vs Sacrificial Anodes for Cathodic Protection of Pipe Lines, William Huddleston, Huddleston Eng. Co.
Operation and Maintenance of Corrosion Control Systems, O. W. Everett, Supervisor of Cathodic Protection Installations, Oklahoma Natural Gas Co.

Afternoon: Plants and Refineries Section

Corrosion Control in Steam and Condensate Systems, M. C. Forbes, Technical Director, Aquatrol, Inc.
Cathodic Protection of Underground Plant and Yard Equipment, Gordon L. Doremus, Cathodic Protection Service.
Corrosion Control in Recirculating Cooling Water Systems, P. G. Bird, Wright Chemical Corp.
Preventing Stress Corrosion, R. C. Schueler, Phillips Petroleum Co.
Motion pictures will be shown at 7 pm.

Wednesday, April 4

Morning:

General Economic Evaluation of Corrosion Control Programs, Karl T. Feldman, Sinclair Pipe Line Co.
Cathodic Protection and Economics of Application, Robert L. Bullock, Interstate Oil Pipe Line Co.
Economic Evaluation of a Corrosion Control Program for Oil Production, R. C. Buchan, Humble Oil and Ref. Co.
Economics of Pipe Line Coatings, A. W. Peabody, Ebasco Services, Inc.

Afternoon: Pipe Lines Section

Planning a Corrosion Control Program, W. T. Burgess, Metropolitan Utilities District, Omaha, Neb.
Economics of Cathodic Protection for a Gas Distribution System, C. L. Woody, United Gas Corp.
Field Testing of Inhibitors, Bonner O. Stampley, Aquaness Dept., Atlas Powder Co.
Internal Coating of Pipe Lines, K. W. Turner, Pipelife Corp.

Afternoon: Instruments Section

Instruments Used in Corrosion Control, Jay R. James, Cathodic Protection Service.
Inspecting for Corrosion, Dwight Evans, Engineering Test Services, Inc.
Measurement of Corrosion Damage, Jim Cowles, Consultant.

Demonstrations will be given and a banquet will be held beginning at 6:30 pm. Toastmaster of R. M. Nee of Robert Nee Co. with F. L. Whitney, Jr., Monsanto Chemical Co., St. Louis as speaker.

Thursday, April 5

Morning:

Safety Value of a Corrosion Control Program, W. Vance Smith, Safety Director, Oklahoma Natural Gas Co.
Selection of the Proper Plastic for Corrosion Control, H. D. Boggs, Fibercast Corp.
There Ain't No Mystery in Paint, Joseph E. Rench, Napko Paint and Varnish Works.
Prevention of Microbiological Corrosion, Joseph N. Breston, Bradford Chemical Co., Inc.

Afternoon: Petroleum Production Section

Corrosion Control in Water Flood, H. L. Bilhartz, Production Profits, Inc.
Protecting Oil Well Casing Against Corrosion, W. C. Koger, Cities Service Oil Co.

Afternoon: General Section

Research Notes in the Relationship of Corrosion and Microstructure, Frederick J. Radd, Continental Oil Co.
History of Carbon Dioxide Corrosion in Gas and Sour Oil Wells, Morris Bock, Sun Oil Co.

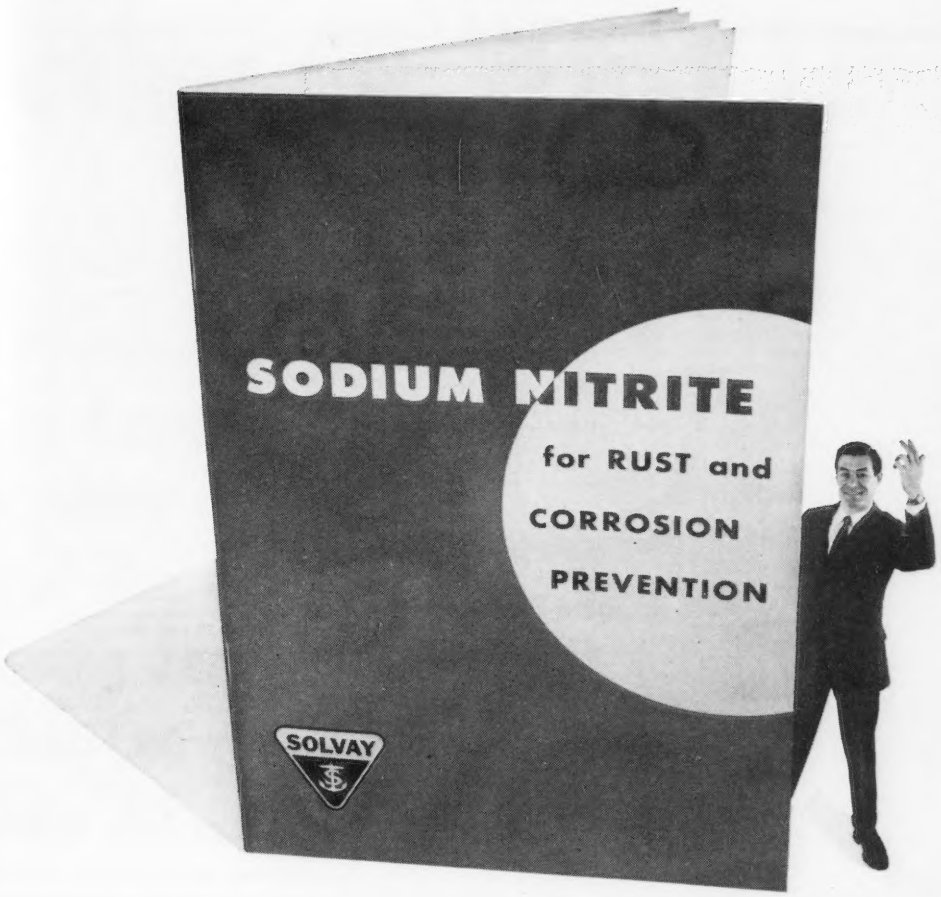
Oil Well Chemical Injection Is Topic at Shreveport

D. F. Taylor and T. B. Holland of Otis Pressure Control, Inc. spoke on the "Development and Operation of the Otis Free Piston Type Bottom Hole Chemical Injector" as used in treating oil and gas wells with concentrated liquid corrosion inhibitors.

During the business portion of the meeting the section elected to donate $50.00 to Centenary College toward purchase of a suitable award to high school students participating in the "Science Fair" to be held on the college campus this spring. This contribution was to be given as a token of appreciation from the section for the assistance Centenary College has given to conducting the annual Shreveport short courses.

The program for the Shreveport Section through May are outlined as follows:

March—Round Table Discussion of NACE National Convention.
April—Field Trip to Steel Mill at Daingerfield, Texas.
May—Film by International Nickel Co. on corrosion.



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Rotary Compressors Are Discussed at Orange

Approximately 40 members and guests attending the February 23 meeting of the Sabine-Neches Section held at The Little Mexico Restaurant, Orange, Texas heard A. D. Hargroder of Mathieson Chemical Corp., Lake Charles, Louisiana speak on the subject of "Corrosion Problems Encountered in the Operation of High Speed Rotary Compressors." Mr. Hargroder gave a review of the corrosion and erosion problems encountered during the past 20 years operation of Mathieson high speed compressors in corrosive carbon dioxide service. The talk which was well illustrated by slides and opaque projections gave details on service life of the rotors, and cases, and their construction and repair.

Central Oklahoma Section Hears W. E. Huddleston

W. E. Huddleston of the Huddleston Engineering Company, Bartlesville, Oklahoma spoke before approximately 25 members of the Central Oklahoma Section at the February 28 meeting on "Protecting Pipe Lines by Use of Rectifiers." Next meeting of the Central Oklahoma Section was scheduled March 27 at which Dan H. Carpenter, Aquaness Dept. of Atlas Powder Company was to discuss "Internal Corrosion in Pipes."

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A 10-Year Index to the material in Corrosion Technical Section 1945-54 inclusive will be published soon.

Brown Talks on Aluminum In Process Industries

R. H. Brown of the Aluminum Company of America spoke at the February 15 meeting of the San Francisco Bay Area Section held in The Allouette Restaurant in San Francisco. His subject was "Aluminum in the Process Industries." Approximately 43 members and guests attended the meeting. Mr. Brown discussed corrosion and metallurgical considerations involved in the use of aluminum alloys for corrosion resistant applications in the field of chemical processing. He discussed also the effects of surface treatment, alloy composition, and other factors related to the use of aluminum.

The new officers for the San Francisco Bay Area installed for 1956 were as follows, G. J. Puckett, Chairman; J. K. Ballou, Vice-Chairman; H. R. Strickland, Secretary-Treasurer.

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More than 230 authors contributed to the Technical Section in Volume 11, Corrosion.

Niagara Section's—

(Continued From Page 67)

zirconium at the U. S. Bureau of Mines; development of melting and fabricating techniques for titanium metal and pioneering of new uses for titanium metal in industry. He is presently active in technical sales development for titanium metal at DuPont.

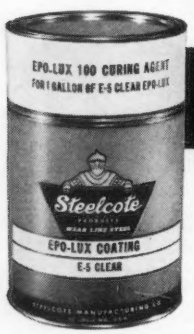
He holds BS and PhD degrees in chemical engineering from the University of Maryland and is a member of the American Society for Metals.

H. O. TEEPLE—Has published a number of articles on corrosion and has compiled annaul reviews on nickel and nickel alloys in Industrial and Engineering Chemistry since 1950. Mr. Teeple is a member of the American Chemical Society, Electrochemical Society and the Technical Association of the Pulp and Paper Industry. He holds a BS in Chemical Engineering (1937) from University of Michigan. His industrial experience includes 7 years with Westvaco Chemical Division of Food Machinery and Chemical Corporation and twelve years with International Nickel Company in Research and Development.

KEMPTON H. ROLL—A Metallurgical Engineer, (Carnegie Institute of Technology; BE, Yale; ME, Polytechnic Institute of Brooklyn), Mr. Roll has been review author for "Industrial and Engineering Chemistry," regular contributor to "Corrosion Forum" and has authored a number of papers on the corrosion characteristics of lead and lead alloys. He is Technical Director of Lead Industries Association and holds memberships in ACS, SNT, ASTM, AIChE, AIME; is chairman of the New York Section ASM; and is a member of NACE Technical Unit Committees T-3B, T-4B, TP-5 and 5A.

MILTON STERN—Milton received his ScD degree in physical metallurgy from MIT in 1952 and was the Weirton Post-Doctoral Fellow from 1952 to 1954. At the present time, he is associated with the Metals Research Laboratories of the ElectroMetallurgical Company as a Research Metallurgist. He has a wide range of interests in the corrosion field and has carried out fundamental research on electrode potential behavior, corrosion inhibitors, cathodic protection, intergranular corrosion, attack by chlorinated solvents and high temperature oxidation. In addition to being a member of NACE, Dr. Stern is a member of ACS, The Electrochemical Society, ASM, AIME, Tau Beta Pi and Sigma Xi.

E. D. WEISERT—E. D. Weisert received a BS degree in metallurgical engineering and a BS in chemical engineering from the University of Michigan in 1950. Upon graduation, he was employed by the Haynes Stellite Company where, until recently, he was head of the Technical Data Branch of Applied Research and Development Department. At present he is with the Metals Research Laboratories investigating metallurgical factors affecting corrosion resistance. Mr. Weisert has contributed several papers on the corrosion and oxidation resistance of high alloy materials. He is a member of NACE and ASM.



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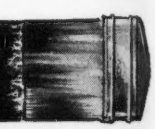

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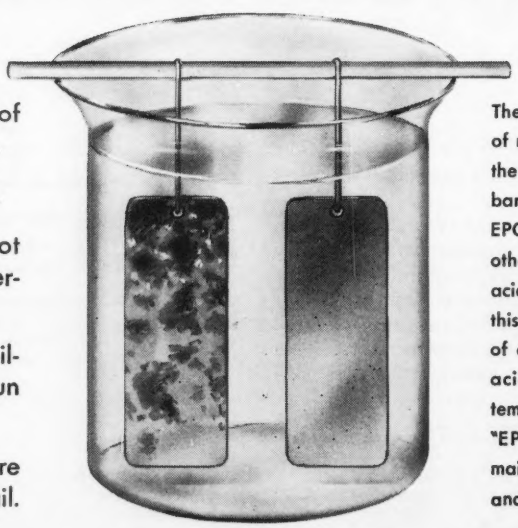

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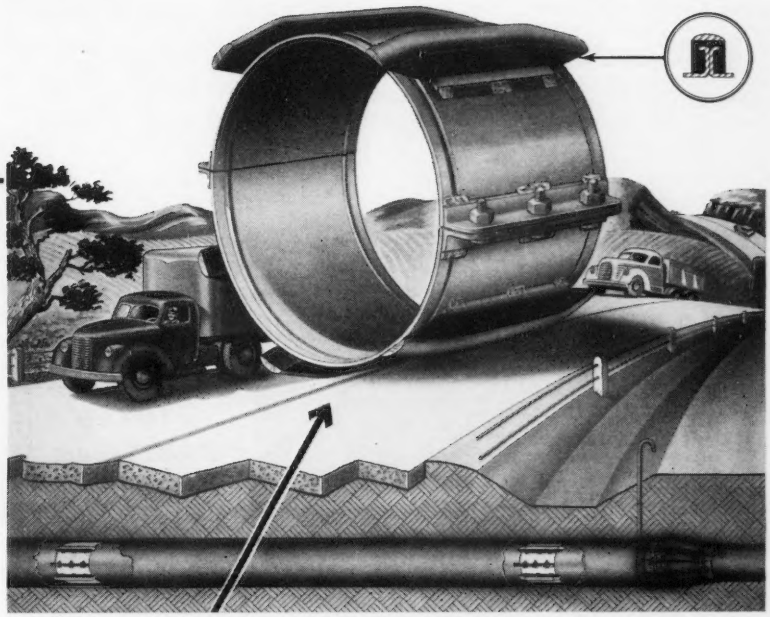

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Fisher M-Scope Pipe and Cable Locators
Detectron Pipe Locators
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234 Attend Seventh Tulsa Corrosion Short Course

The Seventh Annual Corrosion Short Course for Pipeliners sponsored by the Tulsa Section NACE, Feb 15-17 was attended by 234 registrants from 23 states, Canada and Mexico. This is the largest attendance ever recorded for the course.

The planning committee responsible for the organization of the short course included: J. C. Bell, general chairman, Corrosion Services, Inc.; H. L. Nichols, Shell Pipe Line Corp.; A. D. Baker, Phillips Petroleum Co.; A. H. Humble, Gulf Refining Co., Pipe Line Div.; John R. Mason, Stanolind Oil Purchasing Co.; E. W. Lawlor, Allied Paint Manufacturing Co.; R. H. Goodnight, Stanolind Oil Gas Co.; R. A. Walton, Royston Laboratories, Inc.; Walter E. Schott, Corrosion Control, Inc.

Robert M. Smith

Robert M. Smith, plant superintendent for the Houston Division of Koppers Co., Inc., a native of Alaska, died March 17 in a Houston hospital. He was 49 years of age. Besides his widow survivors include a brother, Stuart Smith, Victoria, B.C.; and sisters, Mrs. Hannah Noel, Victoria; Mrs. Mary Gunner, Hammond, B.C. and Mrs. Alice Smith, Newark, N.J. He had been a member of NACE since May, 1948.

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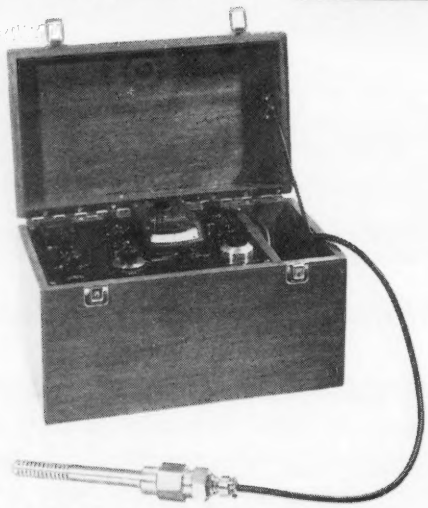

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Submerged Combustion Is Discussed at Dallas Meeting

The February 6 meeting of the North Texas Section, attended by 33 members and guests was held at the Torch Restaurant in Dallas. J. W. Hart, Jr. of Gulf Oil Corporation presented a paper on "Removal of Hydrogen Sulfide from Brine by Submerged Combustion." Mr. Hart's paper was primarily on the development of this new process for removal of sulfides from brine by aeration with exhaust gas from submerged combustion. It was brought out during his talk that submerged combustion was not a mandatory part of the process, but any source of exhaust gas would work just as well.

Hart

A discussion on the organization of the Dallas Utility Corrosion Committee by P. Ray Harrell, Southwestern Bell Telephone Co. was the feature of the North Texas Section meeting March 5.

All utility companies contacted were most cooperative in forming the committee and contributing to the expenses of its formation, Mr. Harrell said. Organization of the utility corrosion committee is proceeding rapidly, according to Mr. Harrell.

Twenty-one members and 12 guests attended the section meeting.

Three Societies Join in April 10 Program at NBS

Three technical societies are cooperating in presenting a program April 10 at the National Bureau of Standards auditorium, East Building, Washington, D. C. Baltimore Section NACE, the Baltimore-Washington Branch of the American Electroplaters Society and the Washington-Baltimore Section of The Electrochemical Society will hear a discussion by F. L. LaQue, The International Nickel Co., Inc. on corrosion testing. A dinner at 7 p.m. at the bureau's South Building will precede the technical program starting at 8 p.m.

Relation of the three sponsoring organizations to corrosion mitigation also will be discussed by speakers from each. Dr. William Blum, retired former head of the Electrodeposition Section of NBS will discuss the relationship of the American Electroplaters Society; Dr. M. C. Bloom, Naval Research Laboratory, Washington, will discuss The Electrochemical Society's activities and George E. Best, Mutual Chemical Division, Allied Chemical and Dye Corp., Baltimore, an NACE director, will talk about NACE contributions.

Rysselberghe Resigns

Pierre Van Rysselberghe, University of Oregon has resigned from the NACE Education Committee because of press of his university duties.

•

Technical material published in Corrosion is abstracted in the biennial Bibliographic Surveys of Corrosion published by NACE

Fontana Cites Eight Ways To Combat Corrosion

Mars G. Fontana, formerly a president of NACE gave Chicago Section members and their guests eight methods for combatting corrosion at the section's February 21 meeting. The eight methods are: 1) Alloying for better resistance. 2) Cathodic protection. 3) Metallic coatings. 4) Inorganic and organic coatings. 5) Alterations of environments. 6) Non-metallic materials. 7) Metal purification. 8) Design. A brief explanation of these methods was given, illustrated with slides. Particularly interesting were the corrosion problems and their curtailment at the Aruba oil refinery off the Venezuelan coast.

Dr. Fontana, who is at Ohio State University was sponsored by the Duriron Co. Host for the fellowship hour was the Electro Rust-Proofing Corp. J. Knauss was senior host, assisted by H. Ludeker, R. Veneigh and A. Gustafson.

●

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●

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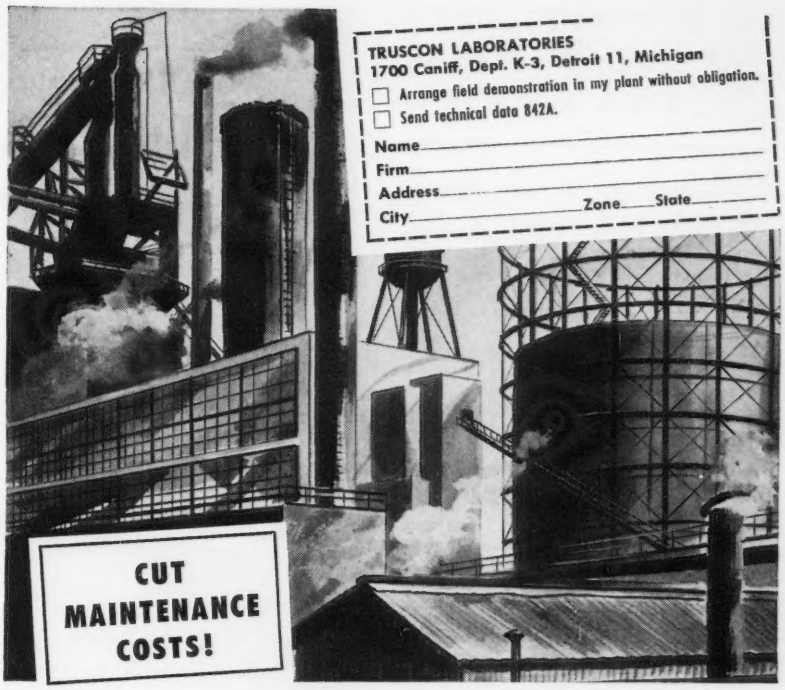

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NACE MEETINGS CALENDAR

Apr.

2 North Texas Section. Dallas, annual picnic.

5 Pittsburgh Section. Mellon Institute, Oakland, Pa.

10 Houston Section. John's Restaurant. Cathodic Protection of External Ship Hulls, H. S. Preiser, Bureau of Ships, U. S. Navy.

17 Chicago Section, Chicago Engineers' Club, 315 S. Federal St., Chicago. Economic Control of Corrosion Under Mildly Corrosive Conditions, E. F. Moorman, International Harvester Company.

17 Cleveland Section. Hotel Manger. Corrosion in the Petroleum Industry, L. Mills.

17 Genesee Valley Section. German Club. Annual business meeting, motion picture.

24 Southwestern Ohio Section. Shuller's Restaurant. Reading, Ohio. Panel Discussion: Protective Coatings; Atmospheric, Cliff Weymiller, Proctor & Gamble Co.; Underground, George Pemberton, Cincinnati Gas and Electric Co.; ceramic, William Barrows, Barrows Porcelain Enamel.

26 Sabine-Neches Section, Orange, Tex. Corrosion Problems in Gas Industry, Joe Waterfield, United Gas Corp.

No date. Schenectady Section. Joint dinner meeting with American Society of Electroplaters.

May

2 Greater Boston Section. Hotel Beaconsfield, Brookline. Organic coatings, Kenneth Tator Associates.

2 Metropolitan New York Section. Chemists Club, New York City.

3 Pittsburgh Section. Mellon Institute, Oakland, Pa.

8 Houston Section. Picnic.

15 Chicago Section. Chicago Engineers Club, 315 S. Federal St. Use of Plastics to Solve Corrosion Problems in Industry, F. L. Whitney, Jr.

17 Kanawha Valley Section. Huntington, W. Va. Fundamentals of Corrosion, Raymond B. Hoxeng.

22 Cleveland Section. Hotel Manger, Cleveland. Stress Corrosion, Julius J. Harwood.

24 Sabine-Neches Section. Orange, Texas. Social program.

No date—North Texas Section, annual picnic.

Instrumentation Literature

Guide to Instrumentation Literature, National Bureau of Standards Circular 567 issued Dec. 14, 1955, 156 pages, $1 can be ordered from U. S. Government Printing Office, Washington, D. C. Over 1200 references are listed. Articles in periodicals are not referenced.

•

A 10-Year Index to the material in Corrosion Technical Section 1945-54 inclusive will be published soon.

•

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GENERAL NEWS

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NATIONAL ASSOCIATION of CORROSION ENGINEERS

A. B. Campbell, Executive Secretary

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Sudrabin to Give Paper at AWWA Meeting May 6-10

External Corrosion Problems in the Water Distribution System by L. P. Sudrabin, Electro-Rustproofing Corp., Belleville, N. J. will be an item on the program of the 75th Anniversary Meeting of the American Water Works Association. The May 6-10 meeting will be held at St. Louis with meetings and exhibits in the Kiel Auditorium.

Nominated as officers for the American Water Works Association were Paul Weir, Atlanta Water Works, president; Fred Merryfield, Oregon State College, vice-president; William W. Brush, Editor, Water Works Engineering, New York, treasurer. Nomination is tantamount to election.

Salt Bath Institute

The Salt Bath Institute has been formed with headquarters at 7307 Euclid Ave., Cleveland 3, Ohio. Edward N. Case, Ajax Electric Co., Philadelphia has been elected president. Next meeting of the institute, consisting of several companies concerned with salt baths will be held April 26 at Cleveland.

Hot Dip Galvanizers

The 1956 annual meeting of the American Hot Dip Galvanizers Association was held March 22-23 at the Drake Hotel, Chicago.

Galvanizers Committee

The Galvanizers Committee, sponsored by The American Zinc Institute will hold its 34th meeting April 23-24 at Hotel Statler, St. Louis.

Texas A & M Short School On Water and Sewage Has Corrosion Control Papers

Several items related to corrosion control were included in the March 4-9 program of the 38th Texas Water and Sewage Works Association's Short School held at Texas A & M College, College Station. These included:

Use of Metallizing in Maintenance, B. L. Grimes, Jr., Leader.

Corrosion and Scale Prevention in Water System Appurtenances, Phillip S. Donnell, Leader.

Progress Report on Stream and Air Pollution, Kenneth S. Watson, General Electric Co., Schenectady.

Reactions of NO_2 and Organic Compounds in Air at Concentrations of Parts Per Million, Edgar R. Stephens, The Franklin Institute, Philadelphia.

Development of Instrumental Methods for the Determination of Small Quantities of Ozone in the Atmosphere, Dale H. Hutchison, Stanford Research Institute, Menlo Park, Cal.

Methods and Devices for Determining SO_2 in Areas and Near Stacks with Speed, Coverage of Area and Low Cost, Louis McCabe, Resources Research, Inc., Washington, D. C.

Industrial Waste Disposal with a Forward Look, Robert L. Wright, Carbide and Carbon Chemical Co., Victoria, Texas.

A panel discussion on trends in water pollution control was held with D. F. Smallhorst, Texas State Dept. of Health, as chairman.

Operation of a Sewage Treatment Plant for Production of Industrial Water Source, C. H. Scherer, Leader.

BOOK REVIEWS

Hydraulic Institute Standards. Loose-leaf, 8½ x 11 inch, in ring binder. 1955. Hydraulic Institute, 122 East 42nd St., New York 17, N. Y. Per copy, Domestic, $4.75; foreign $5.25.

A collection of standards adopted by The Hydraulic Institute. A general section gives information about the institute, which was founded in 1917. Sections covering centrifugal pumps, rotary pumps, reciprocating pumps and a data section covers engineering information about pumped materials and properties of water, pipe, viscosities, friction losses in slurries, nominal composition of alloys, materials for construction for pumping various liquids and an alphabetical index. Pumps of various types are illustrated and their parts identified. Data include sizes, direction of rotation, application standards, capacity and speed limitations among others.

Ceramic Technical Group

Lead Industries Association has formed a ceramic technical committee to consider the uses of lead in ceramics. John H. Koenig, director of the School of Ceramics and the Ceramics Research Institute at Rutgers University is chairman.

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Equipment Services NEW PRODUCTS Materials Literature

Pipelines to the Future, a 64-page analysis of the marketing and use future of plastic pipe to 1975 is available at $1 a copy from Public Relations, Monsanto Chemical Co., Springfield 2, Mass. The booklet includes performance data, costs, and other data including a prediction that pipe applications of plastic by 1975 will consume about 300 million pounds of plastic material a year. A good future for polyvinyl chloride pipe is predicted as soon as processing problems are solved.

Rockwell Manufacturing Co. has acquired the assets of Locomotive Finished Materials Co. of Atchison, Kans.

•

Corrosion Control Reporter, a quarterly publication of Amercoat Corp., South Gate, Cal. includes articles on paint application and cathodic protection and other matters of interest to industrial painters. Copies are available on request.

•

Sonoray, a new ultrasonic-transmission testing device for detecting laminar flaws in plastics and metals, cupping in bolts, brazing defects and similar discontinuities has been developed by Branson Instruments, Inc., 430 Fairfield Ave., Stamford, Conn. The part to be inspected is immersed in liquid and continuous ultrasonic waves are passed through it from the transmitting to the receiving transducer. Discontinuities are detected by their tendency to reduce the energy picked up by the receiver, the loss registering on a meter.

•

Stuart Steel Protection Corp. is now located in Plainfield, N. J.

•

Resources Research, Inc., Wisconsin Building, 4435 Wisconsin Ave. N. W., Washington 16, D. C. is a newly organized firm of consultants specializing in air and stream pollution problems for industry and federal and state agencies. Louis C. McCabe, formerly Scientist Director, U. S. Public Health Service and Frederick S. Mallette, executive secretary of the Committee on Air Pollution Controls and Research Manager of the American Society of Mechanical Engineers, and William S. McCabe are members of the firm.

•

Pyramid conical hole perforated plates in sizes up to 80 by 40 inches are manufactured by Pyramid Screen Co., 264 Mason Terrace, Brookline 46, Boston, Mass. The firm's Arcap non-magnetic stainless alloy, among other metals is used in fabrication. The screens are recommended for a wide variety of industrial applications including many involving corrosive liquids.

•

OKM Model 100-C chemical pumps are designed with a diaphragm type head of Teflon so that pumped corrosives touch nothing but the Teflon. The pump has a maximum total head of 40 feet. The machine is made by O. K. Machine and Tool, Inc. of Waco, Texas.

•

Hydrotol, a device designed to maintain a fixed range of mineral concentration in recirculated cooling water systems is manufactured by Heller Laboratories, 124 Fort Lee Road, Leonia, N. J. After the desired chemical feed and mineral concentration range are determined and set the machine's operation is entirely automatic, manufacturers say. Any range of mineral concentration up to 100 cycles can be maintained and a wide range of chemical feed rates precisely regulated.

•

Teflon surfaces now can be treated by a new method developed by E. I. du Pont de Nemours & Co., Wilmington, Del. so that they can be cemented together.

•

Extruderitems, January, 1956 issue, a periodical available from Bakelite Company, a Division of Union Carbide and Carbon Corp., 30 East 42nd St., New York 17, N. Y. gives extensive information on Bakelite's polyethylene compound used for piping. It is available in sizes from ½ to 2 inches in Schedule 40

(Continued on Page 78)

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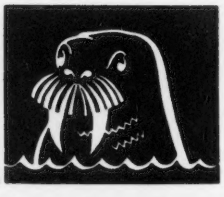

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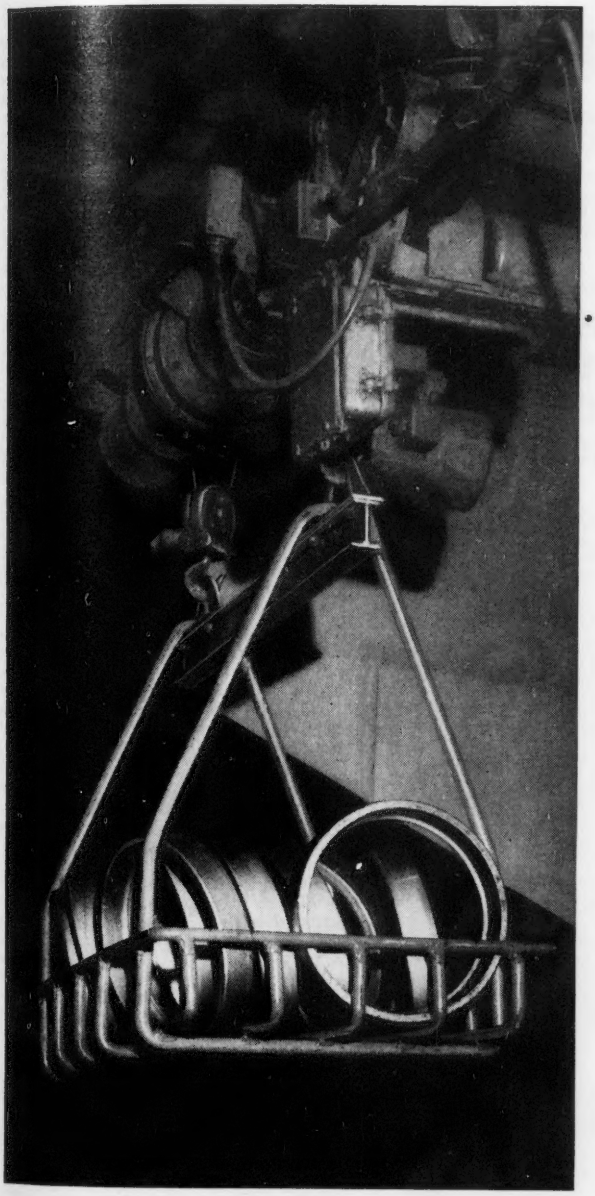

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NEW PRODUCTS

(Continued From Page 76)

and Schedule 80. Recommended applications are described and illustrated.

•

Rokide, a high temperature ceramic coating can now be applied by F. W. Gartner Co., 1010 Milby St., Houston, Texas under license from Norton Co., Worcester, Mass.

•

Roskote cold applied pipe coatings are described in a new folder available from Royston Laboratories, Inc., Blawnox, Pa.

•

Hills-McCanna Company, Chicago will house its Products Division which manufactures diaphragm valves and chemical metering pumps on a new 20-acre tract at Carpentersville, Ill.

•

Illium G Alloy is used by Ampco Metal Inc., Milwaukee in the manufacture of a series of centrifugal pumps. They are available from stock in capacities from fractional flow to 4x3-inch head sizes with maximum capacity of 600 gpm at 150 feet head. Illium G contains but 6½ to 7½ percent iron and is a nickel-chromium-molybdenum alloy.

•

F132 is the designation of a new aluminum casting alloy developed by Aluminum Company of America to replace its older piston casting alloy. The new alloy has properties substantially equivalent to D132, the older alloy, but contains 0.5 percent maximum nickel compared to D132's range of 0.5 to 1.5 percent.

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Mining for Nickel, a new 45-minute sound and color motion picture is available for showing to technical organizations. Prints are available free of charge by bookings through Rothacker, Inc., 729 Seventh Ave., or The International Nickel Co. Inc., 67 Wall Street, New York City.

•

Bart Lectro-Clad Process, an 8-page folder, describes the Bart process by which nickel is deposited on metallic surfaces. Characteristics of the produced coatings are given together with examples of their successful use. Copies are available from Bart Manufacturing Corp., 227 Main St., Belleville 9, N. J.

•

Teflon tape in sections down to 5 miles is being manufactured by United States Gasket Co., Camden 1, N. J. It is treated for cementing with any commercial adhesive. Tape is available from 5 to 60 mils thick in continuous rolls up to 12 inches wide. Sheets are available in 1/32-inch thickness in sizes up to 24x24 inches and in 1/16-inch thickness up to 48x48 inches.

•

PVC pipe fittings and flanges now can be cemented by a new solvent cement which makes a joint stronger than the pipe itself, according to Tube Turns Plastics, Inc., 2929 Magazine St., Louisville 11, Ky. The cement may be applied with an ordinary paint brush and the joint may be handled in an hour after cementing. Working strength is reached in 48 hours

•

Metal and Thermit—United Chromium of Canada, Ltd. will be the name of the combined activities in Canada of the named companies. A new office, warehouse and plant facilities will be constructed in Toronto to house the joint operation.

•

Kaiser Aluminum & Chemical Corp. Kaiser Bldg., Oakland 12, Cal. has published a 24-page booklet describing its heavy press extrusions. Two new 8000-ton presses at the company's Halethorpe, Md. plant operated under a U. S. Air Force contract can produce thousands of hollow shapes up to 17 inches in width or wider and of maximum length of 85 feet. Copies of the booklet are available from Kaiser Aluminum's Industrial Service Div., PR 356, 1924 Broadway, Oakland 12, Cal.

•

Lumicon, a device that amplifies light electronically thousands of times has been developed by Friez Instrument Div., Bendix Aviation Corp. Its uses include production of a television picture thousands of times brighter than that of the fluoroscopic screen and other important uses in radiography, astronomy and in the photographic and associated fields.

•

Wrought Iron plates were used to fabricate more than 5000 feet of 48-inch and 60-inch pipe used at Donaldsonville, La. in an installation designed to pump water from the Mississippi River into the Bayou Lafourche system of waterways. A. M. Byers Co., Pittsburgh, supplied the plate. The bayou Lafourche Pumping Plant project will make it possible to flush the bayou system with fresh river water, improve navigation and provide a ready source of fresh water for a large area in South-

(Continued on Page 79)

NEW PRODUCTS

(Continued From Page 78)

west Louisiana for domestic and industrial use. No extensive fresh ground water resources exist in the area and drainage water was the only source of fresh water after the Mississippi River was separated from the Bayou Lafourche system in 1903 as a flood control measure.

•

A Brighter Tomorrow is the title of a 30-minute, 16 millimeter color film available free of charge to qualified organizations from Bart-Messing Corp., Belleville, N. J. The film deals primarily with electroplating and the manufacture of rectifiers for plating bath use. Also shown are some of the techniques used for preparing precious metal salts and solutions.

•

Craftsmen in Metals for Industry, a 12-page brochure issued by Puget Sound Fabricators, Inc., 3670 East Marginal Way, Seattle 4, Wash. describes the custom metal fabricating services of the firm's 70,000-square-foot plant.

•

Neoprene W. Carboline Company's single package synthetic coating which gives 3 mil film thicknesses per coat is described in Bulletin 701 available from the company at 331 Thornton Ave., St. Louis 19, Mo. Characteristics of the coating, including weathering, abrasion resistance and suitable primers are discussed among other things.

•

Phillips Polyolefin Process will be used under a license agreement by Pullman Incorporated to manufacture a new type of polyethylene compound. The Kellogg Company, a Pullman subsidiary, which also manufactures fluorocarbon products under the Kel-F trade name, will handle the new products. The Phillips process differs from other commercially used methods for production of hydrocarbon resins in that it uses a new type of catalyst. This catalyst produces a unique type of polyethylene and is active in the copolymerization of mixtures of olefins. The company visions a whole new spectrum of resins from the process. Polyethylene produced by the process is reported to be tougher and more heat resistant than current types and to have higher tensile strength, greater rigidity and higher impact strength.

•

Cefco bituminized fibre pipe products made by The Central Foundry Co., Foot of Pacific St., Newark 5, N. J. are described in a new catalog recently issued by the company.

•

PIP push inserts provide female threads in molded plastics, laminates, die-cast alloys, powdered metals and light metals in a drilled or cored hole without tapping. The inserts are made by Heli-Coil Corp., Danbury, Conn.

•

Vinyl or Neoprene coated fabrics for equipment covers, aprons and other uses are available from C. R. Daniels, Inc., Daniels, Md.

•

Alloy Tube Division of The Carpenter Steel Company, Union, N. J. is now marketing polyvinyl chloride pipe. Two grades of pipe are offered, normal with

(Continued on Page 80)

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NEW PRODUCTS

(Continued From Page 79)

high chemical resistance and high impact with slightly reduced chemical resistance. PVC pipe is available in schedule 40 and 80 in nominal size ranging from 12 inch to 4 inch.

●

Repair Cast Iron Parts, a 4-page bulletin available from Readers Service Section, The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y. gives latest information on welding cast iron with Nirod and Ni-Rod 55 electrodes.

●

Perma-Line, Complete Tank and Tank Lining Service, an 8-page brochure available from Perma-Line Rubber Products Corp., 1753 N. Winnebago Ave., Chicago 47, Ill. describes custom lining and tank manufacturing facilities, heat exchangers, rubber lined stel pipe, fittings and valves, PVC pipe, metal and rubber lined fabricated products and Perma-Line No. 124 acid resistant paint and No. 301 liquid Neoprene.

●

Automobile Rubber Co., Inc., 12550 Beech Road, Detroit 39, Mich. will supply on request a sampler containing eleven samples of rubber and elastomeric materials available from the company. The specimens represent standard compounds.

●

Water Vapor in air or gas streams can now be measured on 4-minute cycles with a full scale range of 100 ppm water by volume. Sensitivity of 0.25 ppm by volume and accuracy of about 1 ppm is possible. The instrument was developed by the Mine Safety Appliance Co., Pittsburgh and Esso Research and Engineering Co.

●

Iron and Manganese removal from water is described in Technical Reprint T-144 available from Graver Water Conditioning Co., 216 West 14th St., New York 11, N. Y.

●

Hypalon, E. I. du Pont de Nemours & Company's new synthetic is described in a new 8-page brochure.

●

Al-Con Chemical Co., P. O. Box 8168 New Orleans, La. is selling Shell's VPI crystals in 2-ounce shaker bags or 4-ounce polyethylene spray bottles.

●

Sodium Nitrite for Rust and Corrosion Prevention, a 1956 edition of the booklet has been issued by Solvay Process Division, Allied Chemical & Dye Corp., 61 Broadway, New York 6, N. Y. The booklet describes and illustrates the use of sodium nitrite for corrosion prevention.

●

Alloy and Stainless Steels, Bulletin 175-A of Electric Steel Foundry Co., 2141 N. W. 25th Ave., Portland 10, Ore. describes and tabulates in detail the products of the company designed for corrosion resistance. The 100-page and cover booklet tabulates properties of principal Esco alloys, and rates numerous materials against a long list of corrosives.

●

All-Coat Epoxy coatings available from Shutt Process Equipment Co., 1412 Norman Place, St. Louis 22, Mo. air-dry and produce systems with properties formerly obtained only with high-temperature baking. The coatings will cure at temperatures as low as 40 degrees F, the company says. Objects previously too large to be coated with baked-on systems now can be covered.

●

Checking Corrosion Losses with Graphite Anodes, a bulletin available from Corrosion Control, Inc., 823 S. Detroit St., Tulsa provides data which can be used to estimate the merits of graphite anodes for cathodic protection. Curves, nomographs and other information permit considering the anodes on the basis of resistances, economics and design characteristics.

●

Powder Metallurgy Bibliography, referring to nearly 250 articles and papers printed in more than 50 U. S., English and Canadian periodicals is available from Harper Electric Furnace Corp., 39 River St., Buffalo 2, N. Y.

●

Three Novel Epoxy compounds, all long-chain epoxidized olefins, will be marketed by Becco Chemical Division, Food Machinery and Chemical Corp., Buffalo, N. Y. The new compounds will undergo reactions such as polymerization, isomerization, reduction and ring-opening with a variety of active hydrogen compounds. The new olefin epoxides may be used as acid scavengers, corrosion inhibitors, monomers and as an organic synthesis intermediate among other things.

●

Electrical Testing Laboratories, Inc., 2 East End Ave., New York 21, N. Y. offers numerous services connected with

(Continued on Page 82)

Standard Magnesium VIBRA-PAK ANODES *are uniformly packed which permits evenly distributed electrolytic action over the whole surface of the anode.*

This even distribution means longer lasting, higher operating efficiency. Gives added protection against corrosion loss.

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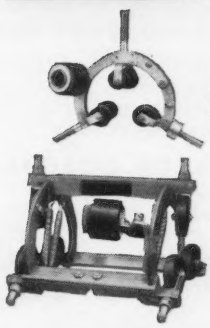

The Tapester Special, available through Dresser, assures speedy, uniform coverage on small diameter pipe.

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NEW PRODUCTS

(Continued From Page 80)

the properties of materials including plastics and laminates.

•

Valvoline Tectyl 506, which give a thin transparent film, is said by manufacturers, Valvoline Oil Co., Freedom, Pa. to be effective in salt or fresh water atmospheres. Protection for periods up to two years is claimed. The material is soluble in petroleum or alkali washes.

•

Quelcor Plastisol Systems are detailed in Data Sheet No. 83 available from Quelcor, Inc., Front and Broomall St., Chester, Pa. Advantages of the plastisol system are described.

MEN in the NEWS

Capt. C. S. Seabring, USN has been named director of research and development of Alco Products, Inc. His responsibilities include the company's nuclear power projects and gas turbine development program.

•

John E. Duesing has been appointed sales manager of the mechanical division of Hagan Corp., Pittsburgh. He has been with the firm since 1939.

•

W. J. Hegerty has been appointed vice-president of Colonial Iron Works Co., Cleveland. He has been sales manager for the past three years.

Hector D. Douglas, Jr. has been named district engineer for the lakes area by the chemical equipment division of Fansteel Metallurgical Corp. His headquarters will be in Cleveland.

•

Andrew Dravnieks has been appointed head of the Corrosion Section in the Materials Division, Enginering Research Dept., Standard Oil Co. (Indiana) Whiting, Ind.

•

Michael C. McFadden, Jr. has joined the Central Atlantic Coast Technical Field Section of the International Nickel Company's Development and Research Division. He is a graduate of Notre Dame and took graduate studies in metallurgy at Lehigh University.

•

John D. Benedito has been appointed general sales manager, Bakelite Company, Union Carbide and Carbon Corp. He joined the firm in 1935 after graduating from Yale.

•

G. W. Dowsley has been promoted to the post of assistant regional manager of Parker Rust Proof Company's South Central District.

•

L. G. Sharpe, corrosion engineer with Napko Paint and Varnish Works, Houston has been named by the firm as its resident representative in the Permian Basin area, with headquarters at Midland.

•

Fritz J. Nagel has been named vice-president of Polymer Processes, Inc., Reading, Pa., a subsidiary of the Polymer Corp. He will direct completion of the developmental efforts on the new Whirlclad coating process and be technical assistant to the president.

•

Melvin Larson has joined Climax Molybdenum Co. as a research chemist at its Detroit Research Laboratories.

•

Henry H. Hausner, general manager of the Penn-Texas Corp. Nuclear Engineering Division has been given the Stevens Institute of Technology Powder Metallurgy Achievement Award, for 1956.

•

Leslie A. Chamber, director of the federal government's air pollution program has been named director of research for the Los Angeles County Air Pollution Control District. He has had more than 25 years of experience in chemical and biological research.

•

Thomas L. Morton has been promoted to the position of assistant plant manager at the Garland, Texas plant of Tempo Aircraft Corp.

•

Thomas M. Butler has been appointed to the new post of director of engineering for Burroughs Corp., Detroit 22, Mich.

•

Earl R. Muir, Jr. has been transferred to Louisville, **Richard T. Burke,** a member of the Houston staff has taken Mr. **Muir's** place as district manager at Seattle, **Vernon Shallcross,** of the Tulsa office has been moved to Denver and **W. C. Robinson,** formerly assistant sales manager Eastern Division has been assigned to special promotional programs by Tube Turns, 224 East Broadway, Louisville 1, Ky.

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Every ferrous metal structure you own (underground pipe lines, oil and water storage tanks, water works equipment, etc.) is being stolen from your profits.
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20-Year Aluminum Atmospheric Test Data Given

Effects of Heat Treating, Coatings on Corrosion Rates Are Included

THE National Bureau of Standards has found that some aluminum alloys can resist corrosion in either a marine or inland atmosphere for at least 20 years.[1] These results were obtained in a long-range study conducted by F. M. Reinhart and G. A. Ellinger of the NBS staff for the Navy Bureau of Aeronautics. Besides determining the corrosion resistance of a large number of aluminum alloys, the study also provides data regarding the effects of heat-treatment and protective coatings on corrosion rates.

The NBS investigation began in the early 1930's. At that time experimental "high-strength" aluminum alloys had been developed for aircraft use, but little was known of their corrosion properties after sustained exposure. There were also many new protective coverings for aluminum such as organic paints and inorganic coatings. The bureau therefore undertook to investigate the commercial and experimental alloys then available, together with the coatings used for surface protection, by exposing them to various weathering conditions for a period of 20 years. The NBS study thus provides data on the 20-year corrosion resistance of aluminum alloys which in some cases have only recently been converted from experimental to commercial status.

The alloys studied (Table 1) included those which could be hardened by heat-treatment and those not susceptible to heat treatment. Among the latter were aluminum-manganese 3004-H34 and aluminum-magnesium 5254-H34.[2] The alloys amenable to heat-treatment included clad and bare aluminum-copper alloys 2017 and 2024. Other alloys contained nickel, cadmium or copper and cadmium. Aluminum-magnesium-silicon alloys, in which hardening is due to the intermetallic compound, MgSi, were also studied. Specimens 0.75-inch by 9 inches long were exposed in selected locations at Washington, D. C., Norfolk, Va. and the Canal Zone. The latter constituted the tropical marine atmosphere, whereas Washington and Norfolk were the temperate inland and marine locations. All of the marine specimens were exposed near the shore line, where they were occasionally wet by spray.

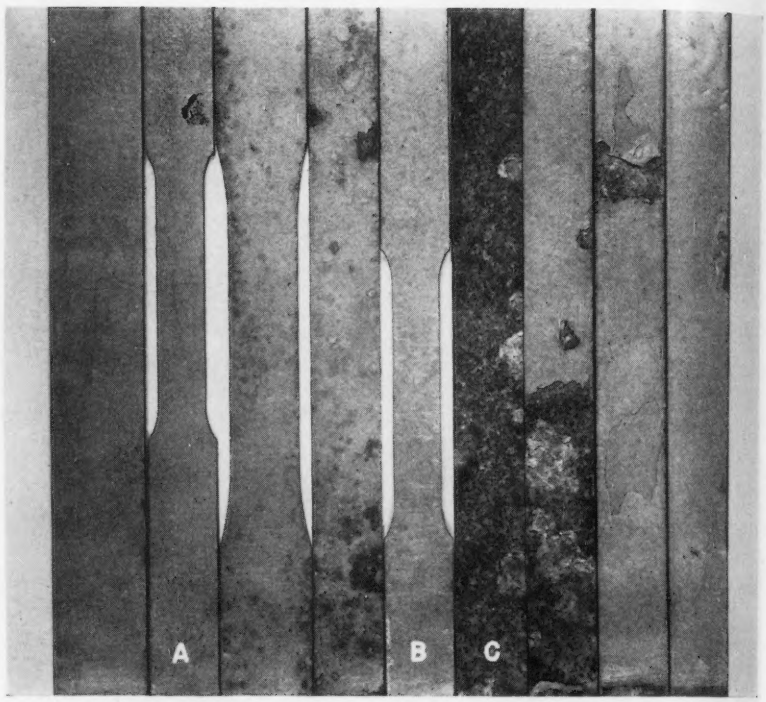


Figure 1—Specimens of aluminum-copper alloy 2017 after seven years' exposure over sea water at Norfolk, Va. All were hot water-quenched, except for A, which was correctly heat-treated. B, although hot water-quenched, was fairly well protected by a long oil ester gum varnish pigmented with aluminum powder. Specimen C, which was severely corroded during exposure, was covered by a clear varnish only.

Different Finishes Tested

Studies were made of the aluminum-copper alloy 2017 with a number of different finishes. Included were samples of clad and bare 2017—several heat-treated by selected methods and some protected with various types of organic or inorganic coatings.

The effects of corrosion on each alloy were evaluated by visual and microscopic examination and by the change in its elongation.[3] The samples were removed at intervals from the racks, beginning three months after the start of the test and were subjected to tensile tests. The tensile strength and elongation after exposure were compared with values obtained on control specimens.

(Continued on Page 86)

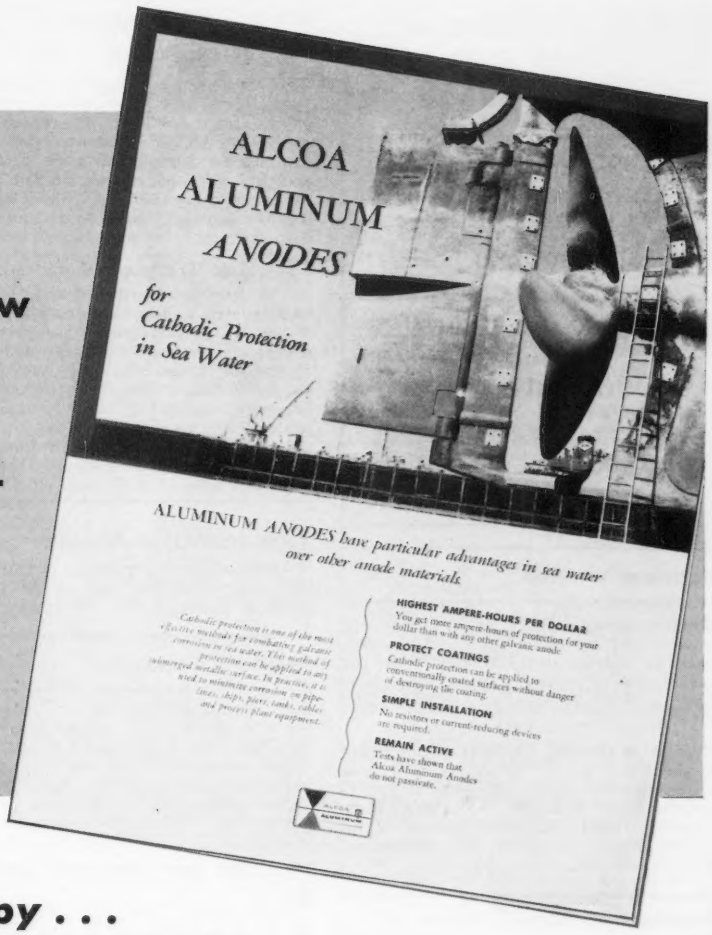
TABLE 1—Chemical Composition of Aluminum Alloys

Designation of Materials[1]		CHEMICAL COMPOSITION, PERCENT BY WEIGHT							
Aluminum Assoc. (or Producer)	ASTM	Al[2]	Cu	Mg	Mn	Fe	Si	Cr	Other Elements
5050-H34	.....	97.98	0.02	1.24	0.00	0.37	0.20	0.19	
5254-H34	GR40A-H34	95.79	.02	3.57	.00	.23	.14	.25	
3004-H34	MG11A-H34	97.32	.10	.89	1.04	.43	.22	....	
X5056-H34	.....	93.73	.05	6.01	0.00	.13	.08	....	
6151-T6	.....	97.61	.05	.51	.01	.52	1.08	.22	
6051-T6[5]	.....	97.95	.05	.61	.01	.38	1.00	....	
Clad 2017-T4[3]	Clad CM41A-T4	93.75	4.10	.59	.58	.48	.50	....	
Clad 2024-T3[3]	Clad CG42A-T3	93.44	4.17	1.59	.57	.14	.09	....	
Clad 2024-T36[3]	Clad CG42A-T36	93.44	4.17	1.59	.57	.14	.09	....	
Nicralium D20187	.....	96.52	.45	.48	.19	.42	.30	.20	Ni, 1.01; Mo, 0.17; Zn, 0.18; W, 0.08
Inalium[4]	.....	96.50	....	.80	....	.25	.45	....	Cd, 2.0
Aeral[4]	.....	92.55	3.75	.80	.25	.25	.40	....	Cd, 2.0
2017-T4	CM41A-T4	94.02	3.94	.56	.57	.47	.44	....	
2017[6]	CM41A	94.17	3.76	.55	.53	.48	.51	....	
2017-T36	CM41A-T36	94.45	4.17	.53	.58	.16	.11	....	
2024-T36	CG42A-T36	93.44	4.17	1.59	.57	.14	.09	....	
2025-T3	.....	93.67	4.20	....	.68	.45	.90	....	

[1] Analyses by the cooperating manufacturer, the Aluminum Company of America, unless otherwise indicated.
[2] By difference.
[3] Analysis of the core material. Cladding 99.75 percent aluminum (1075).
[4] Nominal composition furnished by the manufacturer, Le Société des Brevets Berthelmy de Montby, Paris, France.
[5] Analysis by National Bureau of Standards. (No chromium).
[6] Material subsequently heat-treated at the National Bureau of Standards in various ways.
[7] Furnished by Nicralium Co.

This New Booklet Tells All You Need To Know About Alcoa® Aluminum Marine Anodes . . .

WHY THEY'RE BETTER
WHY THEY LAST LONGER
HOW THEY CUT PROTECTION COSTS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Here's a new booklet that's required reading for anyone interested in buying better protection for ships and marine structures against sea-water corrosion.

It gives the technical story on Alcoa's new Aluminum Marine Anodes . . . in simple, terse language . . . in objective tables and diagrams.

It compares aluminum with other metals point by point. It shows why aluminum provides more ampere-hours per dollar than zinc or magnesium. It shows how and why aluminum needs no current-limiting devices. It shows the 8 basic forms of aluminum anodes . . . designed for protection of hulls, tanks, shore structures subject to sea-water corrosion. It shows that these anodes can be attached by welding, bolting or suspension.

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1958 Achema Congress

The Achema 1958, 12th Chemical Apparatus and Equipment Congress and Exhibition will be held in Frankfurt am Main May 31-June 8, 1958.

Corrosion Congress

The First European Congress of Corrosion will be one of the featured events during the Assembly of Chemical Arts November 22-December 3 at Paris, France.

POSITIONS WANTED and AVAILABLE

- Active and Junior NACE members and Companies seeking employees may run without charge two consecutive advertisements annually under this heading, not over 35 words set in 8 point text type.
- Advertisements to other specifications will be charged for at $10 a column inch.

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Chemist—Experienced in cathodic protection and corrosion engineering work. Desires employment in the West or Southwest. Pipe line company or engineering firm. Reply to CORROSION, Box 56-6.

Protective Coating Chemist—Thoroughly experienced in all inhibitive and protective metal paints. Eighteen years formulating for variety of atmospheres. Masters degree, member several societies, currently group research leader. CORROSION, Box 56-7.

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Inspector:

Minimum five years' experience maintaining and inspecting pressure vessels and oil handling equipment. Thorough knowledge of API and ASME codes for fired and unfired pressure vessels and piping is required.

Salary $9,000 to $11,000 depending on training and experience. Plus a living allowance of approximately $3,600 paid in Saudi riyals.

Write giving full particulars and work experience to—

Mr. H. G. Heinze
Arabian American Oil Company
505 Park Avenue
New York 22, New York

20-Year Aluminum—

(Continued From Page 84)

The control values for elongation were obtained by averaging the original values and the values obtained on specimens stored in desiccated containers for comparable periods of time. Statistical analysis showed no significant differences in these values with respect to time of storage, surface treatment, or paint coating.

Heat Treatment Significant

The bureau found that improperly heat-treated aluminum-copper alloys failed by intergranular corrosion and severe exfoliation with no measurable elongation after exposure, while those properly heat treated performed satisfactorily. However, 2017, when clad with a thin, low-strength alloy, resisted corrosion very well even if incorrectly heat-treated. The alloys 3004-H34, 5050-H34 and 5254-H34 showed excellent resistance to corrosion, as did the cadmium alloy, but alloys containing both magnesium and silicon showed evidence of intergranular attack.

Spot-welded specimens of 3004-H34, clad 2017-T4, and clad 2024-T36 showed no decrease in breaking strength after 1044 weeks in a marine atmosphere or 1140 weeks in an urban atmosphere. When tested, these specimens ultimately sheared through the welds, or the nuggets pulled out of one of the pieces of metal. Likewise, there was no decrease in the breaking strength of clad 2017-T31 joined with 2017-T31 alloy rivets or of aluminum-magnesium 5254-H34 joined with 300 H32 rivets after the same periods of time. However, rivets made of 5056-H32, an alloy having about twice as much magnesium as 5254, were attacked intergranularly, and the heads fell off during the exposure tests.

Protective Coatings Studied

The bureau studied a numbed of protective coatings for aluminum alloys, including oxide coatings formed anodically or by simple immersion in solutions of chemicals, as well as organic coatings of various formulations. These coatings were applied singly and in combination. The bureau's tests showed that the Bengough (chromic acid) anodic treatment did not increase the corrosion resistance of the untreated 2017 alloy in either the ice water-quenched and artificially aged or hot water-quenched conditions. Nor was corrosion resistance improved on similar specimens by the sulfuric-acid anodic process, where the specimen is sealed by immersion in boiling water for 30 minutes.

One of the protective coatings studied was a paint consisting of a long-oil ester gum varnish combined with aluminum powder. When applied over the various oxide coatings, this paint increased protection considerably in most cases. The bureau also studied other paint systems applied to the bare alloy 2017. It was found that two coats of varnish and aluminum powder applied over a zinc chromate pigmented primer gave complete protection to the bare alloy for over 20 years. The elongation of the 2017 clad alloy, even when not painted, was not changed by exposure for 20 years.

Since the bureau's investigation was begun, the compositions of some of the alloys studied have been altered to improve resistance and the use of other alloys has been discontinued altogether. The non-copper alloys, such as 3004 and 5254, are highly resistant to corrosion and are in wide use where lightness, durability and corrosion resistance are required. The aluminum-copper alloy, 2017, has been replaced by clad 2024 for aircraft structural members but is still used for the extruded forms incorporated in airplane assemblies.

1. For further technical details, see Effect of 20-Year Marine Atmosphere Exposure on Some Aluminum Alloys, F. M. Reinhart and G. A. Ellinger, ASTM STP 175 Atmospheric Corrosion of Non-Ferrous Metals (in press).
2. The present Aluminum Association designations are given where applicable, otherwise the manufacturer's designation is given. The first four digets refer to the composition of the alloy. A letter plus one or more digits refers to the temper designations, as follows: H34—strain hardened and stabilized; T3, T31, T34 and T36—solution heat treated and cold worked; T4—solution heat treated; T6—solution heat treated and artificially aged.
3. Elongation of a tensile specimen is defined as the total deformation (stretch) in the direction of load, or per unit of length, caused by a tensile force.

Zinc Institute Meets

The 38th Annual meeting of the American Zinc Institute will be held April 23-24 at Hotel Statler, St. Louis.

Positions Available

Corrosion Engineer with experience in the sale of plastic materials of construction for West Coast Sales position. Excellent opportunity for engineer who can solve corrosion problems using coatings, linings, pipe, duct and related plastic equipment. Please send complete information to CORROSION, Box 56-8.

CORROSION ENGINEER

Graduate Metallurgical or Chemical Engineer with minimum 7 years' work experience which should include analysis and resolving of corrosion problems related to petroleum producing and refining materials and equipment plus steam boilers and other auxiliary equipment.

For work in company's New York Engineering Dept. which requires technical service to operating departments and staff consultant work for the company's overseas operation in Saudi Arabia.

Write outlining personal history and work experience. Please include telephone number.

Recruiting Supervisor, Box 129

ARABIAN AMERICAN OIL COMPANY
505 PARK AVENUE
NEW YORK 22, NEW YORK

CORROSION ABSTRACTS

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2. TESTING

2.3 Laboratory Methods and Tests

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A New Instrument for Measuring Stress in Electrodeposits. J. B. KUSHNER. *Plating*, **41**, No. 10, 1146-1153 (1954) Oct.

The deposit is made on a thin metal disc clamped above a shallow, fluid-filled chamber connected to a manometer. The stress can be calculated from the difference in manometric heights before and after plating. Instrument is termed a Stresometer.—BNF. 9472

2.3.7, 2.4.3, 5.3.2

Sheet and Plated-Metal Measurements. W. A. YATES AND J. L. QUEEN. Paper before Am. Inst. Elec. Engrs., Winter Gen. Mtg., N. Y., Jan. 18-22, 1954. *Trans. Am. Inst. Elec. Engrs.*, Pt. 1 Communication and Electronics), **73**, No. 12, 138-142 (1954) May; *Elec. Eng.*, **73**, No. 10, 873 (1954) Oct.

Non-contacting direct-reading instrument suitable for the continuous inspection of nonmagnetic metals is described. Metal thickness and plating depths are measured. Instrument is composed of an exciter, a phase-angle probe, and a high-input impedance phasemeter. Readings were taken on silver which was plated on a base material of 37 mils of Type 321 stainless steel plated with 1 mil of nickel. (The effect of the magnetic layer of nickel was slight in this case though it might easily become intolerable for other grades of nickel.) Diagram and graph.—INCO. 9483

2.3.7, 3.5.8

Considerations on Deep-Drawability of Sheet Metals. Parts I, II, III. (In French.) P. VAUTHIER. *Metaux*, **28**, No. 339, 437-459 (1953) Nov.; *ibid.*, **29**, Nos. 342, 346, 57-65, 242-258 (1954) Feb., June. In Progress.

Part I. The P.V.I. test is carried out on an electrical machine described by the author in *Metaux*, **28**, No. 336, 91-92 (1953) Feb. On the basis of tests on 18/8 stainless steel sheet, author considers the light thrown by test on capacity for deformation, and relation of P.V.I. and tensile tests.

Part II. The information yielded by the P.V.I. cupping test, anisotropy of sheet and its evaluation, and the stretching occurring during deep drawing are discussed.

Part III. Preferred orientation and internal stresses are considered and the tensile test is related to the P.V.I. test.—BNF. 9515

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BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BTR—Battelle Technical Review, Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association. 81-91 Euston St., London NW 1, England.

CBEC—Centre Belge d'Etude de la Corrosion (CEBELCOR), 17 re des Drapiers, Brussels, Belgium.

CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

EL—Electroplating. 83/85 Udney Park Road, Teddington, Middlesex, England.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California. 2525 East 37th St., Los Angeles 11, Calif.

IIM—Transactions, The Indian Institute of Metals, 23-B, Notaji Subhas Road, P. O. Box 737, Calcutta, India.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum. 26 Portland Place, London W#1, England.

JSPS—Japan Society for the Promotion of Science, Address: Mr. Hayata Shigeno, Secretary, Committee of Preventing Corrosion, c/o Government Chemical Industrial Research Institute, 1-Chrome Nakameguro, Meguro-ku, Tokyo, Japan.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.

MI—Metallurgia Italiana, Associazone Italiana di Metallurgia. Via S. Paola, 10, Milano, Italia.

MR—Metals Review, American Society of Metals. 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

NSA—Nuclear Science Abstracts. United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.

PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London, Waldegrave Rd., Teddington, Middlesex.

SE—Stahl Und Eisen, Verlag Stahleisen, M. B. H., Dusseldorf, August-Thysen Str. 1. Postscheck Koln 4110, (22a) Dusseldorf, Germany.

TIME—Transactions of Institute of Marine Engineers, 85 The Minories, London EC 3, England.

UOP—Universal Oil Products, 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association. 34 Berkeley Square, London W.1.

2.3.7, 3.5.9

High Pressure Oxidation of Metals. Technical Report No. 7. Oxidation of Metals Under Conditions of a Linear Temperature Increase. JOHN P. BAUR, DONALD W. BRIDGES, AND W. MARTIN FASSELL, JR. Utah Univ., Contact DA-04-495-ORD-237, October 15, 1954, 16 pp.

A method of studying the oxidation behavior of metals has been developed wherein the metal sample is subjected to a linear temperature increase at constant oxygen pressure. The advantages of this method over previous isothermal methods are that a rapid preliminary examination of the oxidation behavior of any metal or alloy over any temperature and pressure range can be quickly made, the region of pressure dependence can usually be found in a single experiment, and the number of samples needed is greatly reduced. The linear temperature increase method was applied to the metals tantalum, niobium, molybdenum, copper, zirconium, magnesium, titanium and tungsten. The results are in good agreement with those of previous investigations. Theoretical considerations show that the results could be explained by imposing the conditions of a linear temperature increase on a general type rate equation. (auth.)—NSA. 9359

2.3.7, 6.3.8

Rapid Method for the Determination of the Relative Fatigue Properties of Lead and Lead Alloys. J. MCKEOWN. *Metal Industry,* **85,** No. 15, 305-306 (1954) Oct. 8.

Work done by the British Non-Ferrous Metals Research Association. Progressive loading fatigue tests have shown that the breaking stress is proportional to the endurance limit over a range of lead alloys. The calibration curve thus obtained can be used in the rapid determination of endurance limits of other lead alloys. Reprints will be available from the BNFMRA as R.R.A. 1055P.—BNF. 9532

2.3.9

Extended Tables of Seidel Function for Spectrographers. D. C. CORDINGLEY, L. J. LACEY AND P. J. SANDIFORD. *Applied Spectroscopy,* **8,** No. 2, 92, 94 (1954) May.

Tables relating percentage transmittance and Seidel density.—BNF. 9410

2.3.9, 6.2.5

Nondestructive Test Gives Austenite, Martensite Percentages. S. STORCHHEIM. *Iron Age,* **174,** No. 1, 108-111 (1954) July 1.

Rapid, nondestructive test method combining both magnetic test and X-ray diffraction techniques has been developed to determine percentages of austenite and martensite in fine stainless steel wire. The method is based on relationship of both remanence and coercive forces to austenite and martensite content. Test data for 18/8 stainless wires are presented.—BL. 9388

2.3.9, 6.3.6, 3.7.4

Metallographic Detection of Gamma Phase in Beta-Brass. L. E. SAMUELS. *J. Inst. Metals,* **82,** Pt. 5, 227-228 (1954) Jan.

Mechanical polishing was successfully used to detect fine grain boundary precipitates of gamma phase in tin containing beta brass showing intercrystalline brittleness. Electrolytic polishing develops diffuse dark lines at all grain boundaries of this material. These indications were studied and it was found that ridge and groove contour had been developed at all grain boundaries during electrolytic polishing.—BL. 9464

2.3.9, 6.6.6.

The Carbon Effect in the Spectrographic Analysis of Refractory Materials. R. RICARD. *Applied Spectroscopy,* **8,** No. 2, 75, 78-80 (1954) May.

The effect of graphite additions to refractory powders in the D. C. arc has been studied. Prevention of globule formation and reduction of oxides to more volatile metals may account for enhancement of spectra of the less volatile elements aluminum, magnesium, silicon and titanium.—BNF. 9484

2.3.9, 7.1

Accuracy of Engine Wear Investigation by the Radioactive Tracer Method. YU. S. ZASLAVSKII et al. *Bull. Acad. Sci. URSS* (Izvest. Akad. Nauk. S.S.S.R.), Otdel Tekh. Nauk, No. 1, 54-60 (1954).

Experiments show that accurate quantitative and qualitative data are obtained using different cooling water temperatures, lube oils, etc. 4 tables, 8 figures, 4 references. Translation available: Assoc. Tech. Services, Box 271, East Orange, N. J.—ATS. 9460

2.4 Instrumentation

2.4.2

Eddy Current Type Diameter Gauge for Corrosion Measurements. WILLIAM B. DOE. Argonne National Lab. U. S. Atomic Energy Comm. Pubn., ANL-5227, Sept., 1954, 16 pp.

An eddy current type instrument, which will detect one ten millionth inch change in the radius of a metal rod, is described. This sensitivity was required to determine the corrosion rates of corrosion-resistant metals without an unduly long corrosion period. Surface oxide films do not interfere with the measurements. (auth).—NSA. 9519

2.4.3

Factors in the Use of Black Lights for Fluorescent Inspection. J. E. CLARKE. *Non-Destructive Testing,* **12,** 21-25 (1954) July-Aug.

Light sources, intensity requirements and operation, care and maintenance of equipment. Diagram, graphs.—MR. 9514

2.4.3, 6.4.2

New Possibilities of Non-Destructive Testing in the Aluminium Manufacturing Industry. (In German). R. POHLMANN. *Aluminium,* **30,** No. 2, 47-60 (1954) Feb.

Detection of cracks, segregations and inclusions using high frequency ultrasonic waves. Description of the construction of the "Sonometer" instrument.—BNF. 9324

2.6 Preparation and Cleaning of Specimens

2.6

Corrosion. MARS G. FONTANA. *Ind. and Eng. Chem.,* **46,** No. 12, 77A-78A, 80A (1954) Dec.

Describes cleaning of metallic specimens after exposure. Photograph, table.—BTR. 9438

2.6

Corrosion. MARS G. FONTANA. *Ind. and Eng. Chem.,* **46,** 93A-94A, 96A (1954) June.

Sample preparation and techniques in corrosion testing. Photographs.—MR. 9440

2.6, 2.3.7

Tension Specimens Made by Photoengraving Technique. R. L. DOWDELL AND W. B. F. MACKAY. *A. S. T. M. Bull.,* No. 201, 65-66 (1954) Oct.

Tension tests on very thin copper-nickel alloy sheet did not give consistent results owing to distortion of the edges if mechanical methods were used for producing specimens. The difficulty was overcome by using a photoengraving technique involving etching with ferric chloride solution.—BNF. 9765

3. CHARACTERISTIC CORROSION PHENOMENA

3.2 Forms

3.2.2, 6.2.1

The Diffusion of Hydrogen in Iron and Ferritic Steels. E. W. JOHNSON AND M. L. HILL. Westinghouse Research Labs. *Acta Metallurgica,* **3,** 99-101 (1955) Jan.—NSA. 9420

3.2.2, 6.3.15, 1.6

Hydrogen Contamination in Titanium and Titanium Alloys. Part I. Hydrogen Embrittlement in Alpha-Beta Titanium Alloys. (Report of WADC Technical Meeting October 29, 1954). RALPH J. KOTFILA AND HARRIS N. BURTE, eds. Materials Lab., Wright Air Development Center Publication, Technical Report Number 54-616 (Pt. 1), Jan. 1955, 183 pp.

Hydrogen contamination in α-β titanium alloys can cause low ductility in slow strain rate, room temperature tensile tests, and premature brittle fracture in room temperature rupture tests. The combination of stress concentrations and hydrogen contamination can lead to a drastic decrease in the load carrying capacity of these alloys. Another result of hydrogen contamination is increased susceptibility to embrittlement as a result of exposure to stress and elevated temperature. A maximum hydrogen content of 125 ppm is suggested as a tolerance for aircraft quality α-β titanium forging alloys. Data are presented which show that in the future it will be possible to produce alloys which have much higher tolerances for hydrogen. (auth).—NSA. 9421

3.2.3, 6.2.4, 3.5.8

Hollow Drill Steels. W. W. DURAND. Crucible Steel Company of America. *Mining Congress J.,* **40,** No. 1, 44-46 (1954) Jan.

Some observations on the scaling rate at various times and temperatures. Results of excessive scaling are undersize threads, loose fitting bits and ultimate mechanical failure from unfavorable stress distribution. Scaling characteristics of 3 drill steel analyses were investigated. Investigation proved that amount of scaling increases with time and temperature. Photographs and graphs.—INCO. 9772

3.2.3, 5.9.4

The Examination of Oxide Films by Reflection Electron Microscopy. J. S. HALLIDAY AND W. HIRST. *Proc. Phys. Soc.* (England), Sec. B, **68,** Pt. 3, No. 423B, 178-181 (1955) Mar. 1.

An investigation by reflection electron microscopy of the change in surface topography of metals when oxidized is described. The effect of oxidation on the surface structure of aluminum is shown in reflection micrographs of an electropolished surface. The general surface is flatter than O.1° although there are slight

undulations which cause intensity variations from place to place; these occur most particularly at the grain boundaries. There are only a few surface features which are smaller in size than the crystal grains. A micrograph obtained from a similarly electropolished specimen which had been oxidized in air at 500° C. for 30 min. revealed a thin film of amorphous aluminum oxide which was not detectable by eye or under the optical microscope. The general surface, over areas comparable with the grain size, remains flat to better than 0.1° but the film has acquired a somewhat granular appearance. It appears that this film adheres well to the underlying metal surface and very largely maintains the initial surface topography. This film gave better protection against frictional damage than did the thinner oxide film forming at room temperature. This phenomenon was contrary to results with other metals examined.—ALL. 9425

3.2.3, 6.3.14

Study by Electron Diffraction of the Oxidation of Tin Under Reduced Pressure. (In French). JEAN-JACQUES TRILLAT, LEA TERTIAN, AND MARIE-THERESE PLATTARD. *Compt. rend.*, **240**, No. 5, 526-528 (1955) Jan. 31.

On heating pure tin in a vacuum, it was possible to observe the fusion phenomenon and gradual transformation into stannous oxide and stannic oxide. Two references.—MR. 9280

3.3 Biological Effects

3.3.4, 1.3

Microbiological Corrosion of Iron and Steel. DAVID M. UPDEGRAFF. *Corrosion*, **11**, No. 10, 442t-446t (1955) Oct.

A critical review of the literature on microbiological factors involved in the corrosion of iron and steel is presented. A brief account of the historical aspects of the subject is given along with a discussion of the mechanism by which microorganisms affect corrosion, a description of some typical examples of microbiological corrosion and a discussion of methods used to prevent microbiological corrosion.

It was found that while microorganisms do not corrode iron or steel, they often produce major physical and chemical changes in the environment. These changes may influence the electrochemical processes responsible for corrosion and this markedly accelerates (or under different conditions decelerates) the corrosion rate.

It was found that microorganisms sometimes coat metal surfaces, influence galvanic cells, affect pH or acidity, affect redox potentials, catalyze chemical reactions which influence corrosion, and change oxygen tension. A description of how anaerobic bacterial corrosion is carried out by sulfate-reducing bacteria is given.

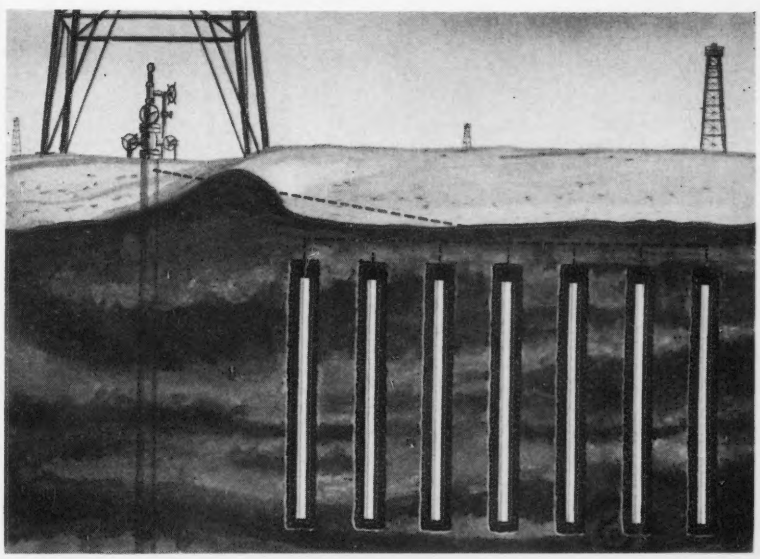
Methods of alleviating microbiological corrosion are found to include cathodic protection, protective coatings, germicide treatment of water, and alkali treatment. 9756

3.5 Physical and Mechanical Effects

3.5.8, 3.5.9

The Creep-Rupture Properties of Aircraft Sheet Alloys Subjected to Intermittent Load and Tempearture. G. J. GUARNIERI. Cornell Aero. Lab., Inc. Paper before Am. Soc. Testing Materials, Symp. on Effect of Cyclic Heating and Stressing on Metals At Elevated Temperatures, 57th Ann. Mtg., Chicago, June 17, 1954. ASTM Special Technical Pubn. No. 165, 105-146; disc. 147-148 (1954).

Type 321 stainless steel at 1200 and 1350°F, N-155 alloy at 1350 and 1500°F, and Inconel "X" at 1250 and 1500°F were among six alloys studied. Intermittent-load-constant-temperature tests were conducted with cycle of 1-hr-load-on, 1-hr-load-off in most cases although several alloys were also subjected to an 8-hr-on, 8-hr-off load cycle. Intermittent-temperature-constant-load tests were made using a 2-hr cycle with specimen at temperature 1 hr and cooled 1 hr. Wide variety of effects were produced by intermittent-load and temperature conditions. Stability of microstructure was significant variable controlling alloy response to cyclic conditions. Acceleration of creep and rupture was induced by intermittent loading where such processes as overaging, relaxation, recrystallization, and loss of ductility occurred, as in N-155 at 1350°F. Retarding of creep and rupture occurred in those alloys where increase in ductility and creep recovery developed because of intermittent-load cycle. Intermittent heating produced acceleration of creep and rupture in a number of cases, particularly where susceptibility to intergranular oxidation and cracking was aggravated by thermal stresses as in Inconel "X" at 1500°F particularly, and 321 stainless steel at 1200 and 1350°F. Tables, graphs, photomicrographs, 6 references.—INCO. 9447



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47a

3.5.8, 2.3.7, 6.2.5

Stress Corrosion of 12% Chromium Stainless Steel. W. L. BADGER. Paper before Society of Automotive Engineers, Ann. Mtg., Detroit, Jan. 12, 1954. *SAE J.*, **62**, 307-310; disc., 310-313 (1954).

Investigation of stress corrosion cracking, a combination of stress and corrosive action, in compressor rotor blades of 12 percent chromium, type 403 stainless steel. A laboratory method for producing similar failures using a corroding solution of 1-1 hydrochloric acid +1 percent selenium dioxide was worked out, and resultant data showed that a tensile stress of about 50,000 psi was required to cause cracking. The data fell in a pattern similar to fatigue or endurance curves. It was recommended that compressor blades be stress relieved at 950°F. This treatment eliminated cracking. Similar testing of 12 percent chromium-molybdenum-vanadium, 12 percent chromium-tungsten-nickel, and 12 percent chromium-molybdenum-tungsten-vanadium alloys indicated the alloys to be superior to 403 in regard to stress corrosion cracking. Illustrations, photomicrographs, graphs, tables.—INCO. 9345

3.5.8, 2.3.7

Triaxial Stresses Caused by Notches. A. F. C. BROWN. *Brit. J. Applied Physics*, **5**, No. 8, 280-284 (1954) Aug.

Photoelastic stress analysis and mechanical tests on steel specimens; it is concluded that the stress distribution at the middle of the bar has much more effects in the initiation of general yield than has that at the root of the notch.—BNF. 9285

3.5.8, 2.3.7

The Effect of Compressive and Shearing Forces on the Surface Films Present in Metallic Contacts. M. COCKS. *Proc. Phys. Soc.*, Sec. B, **67**, No. 3, 238-248 (1954).

Two electrical Methods are described for studying the nature of the contact between metals. Apparatus is described for measuring contact resistance under compressive and/or shearing loads. Cylindrical specimens of a number of metals were used. An analysis of the results shows that oxide films are broken down only with difficulty; no penetration was observed during normal loading, and in the case of tungsten, molybdenum, and tungsten carbide the films seemed to remain intact even during sliding. These results have been confirmed by a second method using thermo-electromotive force measurements. —MA. 9408

3.5.8

The Mechanism of Fatigue in Metallic Materials. (In Swedish). B. STROM. *Jernkontorets Annaler*, **138**, No. 1, 17-38 (1954).

Reviews published literature on fatigue fracture, giving typical examples of fatigue curves for various materials and the influence of various factors on fatigue limit. Theories of fatigue crack formation are summarized with reference to metallographic and X-ray evidence. 60 references. —BNF. 9390

3.5.8

Stress Corrosion. M. G. FONTANA. *Ind. and Eng. Chem.*, **46, No. 3,** 99A-100A, 102A (1954) Mar.

Metals and alloys, including copper alloys, Inconel, Monel, nickel, steels, stainless steels, and titanium, and environments in which stress corrosion may occur are listed. Number of theories proposed concerning the mechanism of stress corrosion is discussed. A film titled "A Study of Stress Corrosion" is available from the author's laboratory.—INCO. 9444

3.5.8

Crack Propagation. F. FORSCHER. *Welding J.*, **33**, No. 11, 579s-584s (1954) Nov.

Survey of crack propagation due to mechanical action. Relationship of the "fracture toughness" to tensile strength and work hardening is developed. 16 references.—BNF. 9690

3.5.8

Possible Mechanism of Fracture of a Metal in a Corrosive Medium. (In Russian.) IU N. RABOTNOV. *Bull. Acad. Sci. USSR*, Technical Sciences Section (Izvestiia Akademii Nauk SSSR, Otdelenie Tekhnicheskikh Nauk), No. 6, 53-56 (1954) June.

Mathematical investigation of stress corrosion. Graph. 1 reference.—MR. 9478

3.5.8

Mechanism of Fretting Corrosion. H. H. UHLIG. Paper before Am. Soc. Mech. Engrs., Lubrication Activity Div. & Applied Mechanics Div., Semi-Ann. Mtg., Pittsburgh, June 20-24, 1954. ASME Preprint No. 54-SA-5, 1954, 7 pp.; *J. Applied Mechanics*, **21**, No. 4, 401-407 (1954) Dec.

Mechanism of fretting corrosion includes a chemical and a mechanical factor, with observed damage, in general, resulting from both. An asperity rubbing on a metal surface produces a track of clean metal which immediately oxidizes, or upon which gas rapidly adsorbs. The next asperity wipes off the oxide or initiates reaction of metal with adsorbed gas to form oxide. This is the chemical factor. Asperities dig below the surface to cause a certain amount of wear by welding or shearing action in which metal particles are dislodged. This is the mechanical factor. Metallic debris produced by fretting converts partially to iron oxide by secondary fretting action of particles rubbing against themselves or adjacent surfaces. This accounts for the fact that ferric oxide is found by X-ray to be the major corrosion product and metallic iron is present, if at all, in only very small amounts. The quantitative expression for fretting corrosion has been derived. 23 references.—INCO. 9389

3.5.8, 3.5.9, 7.10

Allowable Working Stresses for Springs. H. C. R. CARLSON. *Wire and Wire Products*, **29**, No. 11, 1318-1323, 1359, 1361 (1954) Nov.

Types of stresses to which springs may be subjected in service; gives fatigue curves showing allowable working stresses for various materials. Properties of 12 spring steels and 17 alloys suitable for use at elevated temperature with permissible temperature and stresses.—BNF. 9707

3.5.8, 6.2.3, 6.2.4, 3.7.1

Stress-Corrosion Cracking in Mild Steels and in Steels of Low Alloy Content. E. HERZOG. Paper before 26th Cong. Intern. de Chimie Industrielle, June, 1953. *Corrosion et Anti-Corrosion*, **2**, Nos. 1, 2, 3, 3-13, 57-68, 91-97 (1954) Jan.-Feb., Mar.-Apr., May-June.

Evaluation and description of tests used in research on stress-corrosion cracking. Data on influence of compositions, fabrication, heat-treatment and structures of mild and low-alloy steels on behavior in environments where stress-corrosion cracking occurs are given. Examples of service experience in presence of sodium hydroxide, nitrates and hydrogen sulfide are given. Electrochemical interpretation is disclosed of the phenomenon of stress-corrosion cracking. Data on aluminum-chromium-molybdenum, chromium-manganese-molybdenum-vanadium, low-alloy nickel-chromium and complex nickel-aluminum-chromium steels containing manganese and molybdenum are included as well as a section on influence of small amounts of nickel on transformation curves of aluminum-chromium and 3 percent chromium steels. —INCO. 9735

3.5.8, 6.3.6

Strain-Ageing in 70:30 Brass. B. B. HUNDY. *J. Inst. Metals*, **83,** Pt. 3, 115-116 (1954) Nov.

Strain-ageing has been observed during some tensile tests on 70:30 brass strip, although no initial yield could be detected. Results are interpreted in terms of Cottrell's theory [*Phil. Mag., Ser. vii*, **44,** 829 (1953)] which amplifies the idea that a stepped stress/strain curve is due to the solute atoms diffusing through the lattice at a speed sufficient to allow strain-ageing while plastic deformation is in progress. It is not thought that strain-ageing in annealed material of this grain-size (0.055mm.) is of any industrial significance. Graphs, 6 references. 9692

3.5.8, 6.3.6, 3.8.4, 3.2.2

The Effect of Internal Oxidation on the Fatigue Properties of Copper Alloys. J. W. MARTIN AND G. C. SMITH. *J. Inst. Metals*, **83,** Pt. 5, 153-165 (1955) Jan.

Polycrystalline and single-crystal specimens of copper (pure, with 0.3% silicon, and with .25% and .05% aluminum), containing dispersed non-metallic phases were prepared by an internal-oxidation technique, and their fatigue properties compared with those of unoxidized material, using a constant-strain Chevenard Microtorsion machine. Fatigue-resistance of polycrystalline specimens is decreased by internal oxidation, due to intergranular weakness. Fatigue-resistance of single crystals is increased by internal oxidation to an extent depending on fineness of the oxide dispersion; the finer the dispersion, the longer the fatigue life at any given strain. Nature, shape, and size of particles in disperse phase were examined by electron-microscopic methods. Electron-micrographs, graphs, 13 references.—INCO. 9419

3.5.8

Fretting Corrosion as a Cause of Fracture of Shrunk-On Crank Shafts of Large Piston Engines. (In German) FRANZ JAKLITSCH. *Stahl und Eisen*, **75,** No. 2, 97-98 (1955) Jan. 27.

Reduction of fatigue strength by combined abrasion and corrosion. Table, photographs. 3 references.—BTR. 9399

3.5.8, 3.5.9, 8.9.1

Structural Safety of Aircraft: Statistical and Probability Concepts. A. G. PUGSLEY. *J. Roy. Aeronaut. Soc.*, **59,** No. 534, 415-431 (1955) June; *Engineering*, **179,** 376-377 (1955) Mar. 25.

Effect of scatter of fatigue test results, corrosion fatigue, effect of rapid changes in surface temperature, relation of probability of failure to the load factor, desirability of relating safety margins in civil aircraft to the size of aircraft concerned.—BNF. 9646

3.5.8, 6.2.4, 6.2.3

The Effect of Martensite on Sulfide Stress Corrosion Cracking. M. F. BALDY AND R. C. BOWDEN, JR. *Corrosion*, **11,** No. 10, 417t-422t (1955) Oct.

Rapid failures of tubing in sour condensate wells have led to an investigation of possible causes of these failures. The presence of hydrogen sulfide points to sulfide stress corrosion cracking as the cause. The effect of untempered marten-

site was studied as to its bearing on the susceptibility of steel to sulfide stress corrosion cracking.

Test bars from API Grade N-80 tubing previously annealed were heated into the austenitizing range, furnace cooled to temperatures above, within, and below the transformation range, and then water quenched. Over this range of pre-quenching temperatures, samples were produced having from 0 percent to 100 percent martensite. After machining to final size, test bars were two-point beam loaded, with a constant moment between loading points, and immersed in a bath of distilled water saturated with hydrogen sulfide and carbon dioxide. All samples were loaded to various stress levels below the yield strength.

The susceptibility of steel of the chemical composition commonly used in API Grade N-80 pipe (80,000 psi minimum yield strength) to sulfide stress corrosion cracking under these conditions was found to fall into three categories, depending on the percentage of martensite present.

1. From 0 percent martensite to between 30 percent and 35 percent martensite, the steel is not susceptible.
2. From 30 percent to 35 percent up to 75 percent to 80 percent martensite, the permissible applied stress to avoid failure decreases with increase of this phase.
3. Over 75 percent to 80 percent martensite, apparently any applied stress will cause failure.

It was found that when martensite begins to show evidence of continuity in the microstructure, the steel becomes susceptible to sulfide stress corrosion cracking. 9758

3.5.8, 6.4.2

Fatigue Phenomena in High-Strength Aluminium Alloys. R. F. HANSTOCK. *J. Inst. Metals,* **83,** No. 1, 11-15 (1954) Sept.

Increase in damping capacity preceding fatigue failure of aluminum alloys L.65 and DTD 683 is associated with precipitate instability. Localized bands of precipitation in DTD 683 give rise to fatigue cracks. Fatigue strength depends on magnitude of stress required to initiate precipitation and on strength of overprecipitated region.—BNF. 9186

3.5.9, 3.5.8

Deterioration of Metals From Prolonged Loading at Elevated Temperature. YA. B. FRIDMAN AND B. A. DROZDOVSKII. *Doklady Akad. Nauk SSSR,* **95,** No. 4, 793-796 (1954) April 1.

Detailed study of the "deterioration curve" of a chrome-nickel alloy due to prolonged static loading at elevated temperature. Micro-nature of the failure is analyzed. 3 figures, 9 references.—ATS. Translation available: Assoc. Tech. Services, Box 271, E. Orange, New Jersey. 9240

3.5.9, 3.5.8, 6.2.4, 6.2.5

Experiments on the effects of Temperature and Load Changes on Creep-Rupture of Steels. G. V. SMITH AND E. G. HOUSTON. Paper before Am. Soc. Testing Materials, Symp. on Effect of Cyclic Heating and Stressing on Metals at Elevated Temperatures, 57th Ann. Mtg., Chicago, June 17, 1954. ASTM Special Technical Pubn. No. 165, 67-76; disc., 77-78 (1954).

Four steels—2.25 percent chromium, 1 percent molybdenum; 18 percent chromium, 8 percent nickel (0.3 percent car-

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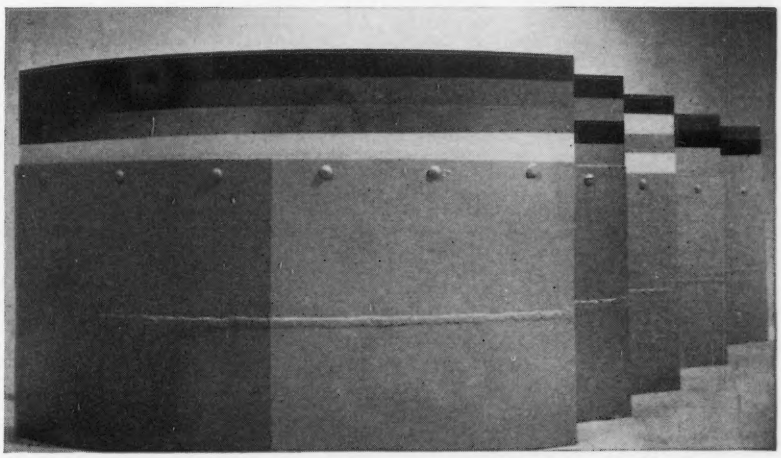

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bon); 18 percent chromium, 8 percent nickel (titanium); and 12 percent chromium, 0.5 percent molybdenum—were studied with most extensive tests made on 18 percent chromium, 8 percent nickel, 0.03 percent carbon steel (type 304L) in the belief that it would be relatively free from changes in microstructure which would complicate interpretation of results. Several tests were made on type 304L steel at 1100 and 1500°F in which final creep-test load was attained by 10 equal increments or decrements at 48-hr intervals over a period of 480 hr. A number of creep tests were made during which temperature was continuously cycled to 50 ± 5°F above and below mean test temperature at frequency of 0.5 cycle per hr. Several interrupted creep-to-rupture tests were made with 304L steel. Generalization regarding changes in creep rate or time to rupture does not appear possible on basis of relatively few results available. J. R. McDowell (Westinghouse Research Labs.) discusses experimental work on creep properties of 19-9 DL using an intermittent program of load and temperature. Tables, graphs, 9 references.—INCO. 9381

3.5.9, 1.4

Bibliography of Recent Literature on Metals at Elevated Temperatures. G. M. SNEIDER AND F. E. MANLEY. Special Library Assoc. Rept., 26 pp., 1951, unclassified 1954 (on micro-cards).

A bibliography is presented of literature relating to the properties and uses of metals at high temperatures for the period 1949-1951.—MA. 9370

3.5.9.

Influence of Temperature on the Strength of Brittle Metallic Substances. (In Russian). V. V. BARON AND E. M. SAVITSKII. *Doklady Akad. Nauk S.S.S.R.*, **94,** No. 2, 269-273 (1954) Jan. 11.

Effect of temperature (up to 1000°C) on the tensile strength, compressive strength and hardness of copper, germanium, silicon, cobalt, nickel-silicon, copper-silicon and cobalt-silicon.—BNF. 9344

3.5.9

The Optical Behaviour of Metals at High Temperatures. (In German.) G. GRASS. *Z. Metallkunde,* **45,** No. 9, 538-547 (1954) Sept.

Reflectivity of iron, nickel, copper, cobalt and manganese in the visible range was found to vary very little with temperature up to 1200°C; phase transformations in iron and manganese had a marked effect, though the Curie points of iron and nickel did not. Spectral U.V. reflectivity of silver up to 950°C; effect of surface recrystallization and oxidation.—BNF. 9495

3.6 Electrochemical Effects

3.6.2, 6.3.19

Distribution of the Attack, Voltage and Currents in Corrosion by Differential Aeration. Research on Zinc. (In Italian.) G. BIANCHI AND R. ALETTI. *Metallurgia Italiana,* **46,** No. 10, 347-353 (1954) Oct.

The determination of the distribution of the currents was carried out on a sample of zinc in conditions of differential aeration. On the basis of the results obtained a model was realized for the determination of the corresponding distribution of the currents. The relative intensity of the process of corrosion by differential aeration, of the water line corrosion, local cell corrosion and the distribution of the resulting global attack, was determined also with the aid of aeration curves.—MI. 9493

3.6.6, 6.2.3, 6.4.2

Corrosion of Metals in Alkaline Solutions. First Rept. On the Contact Corrosion of Dissimilar Metals. Part I. Mild Steel-Aluminum Alloy. H. ENDO, N. OOTANI AND S. SHIMODAIRA. *J. Japan Inst Metals,* **18,** No. 4, 211-214 (1954) April.

The galvanic corrosion of mild steel-aluminum alloy couple was investigated in sodium carbonate alkaline solution at 30°. The results are summarized as follows; 1) As to mild steel in contact with aluminum alloy, the weight loss hardly increases at pH<8, but decreases remarkably at pH>8 owing to cathodic protection. 2) On the other hand, as to aluminum alloy in contact with mild steel, the electro-chemical reaction (I) $H\cdot \rightarrow H$ becomes the rate determining step when the amount of OH^- is large, but when it is small, the purely chemical reaction (II) $Al(OH)_3+NaOH \rightarrow NaAlO_2$ becomes the rate-determiner. Within the former range, the weight loss of aluminum alloy increases remarkably by contact with mild steel compared to that of aluminum alloy alone and it decreases within the latter range. 3) The boundary where the reaction (I) or (II) becomes rate-determining is related to the pH value of the solution and rpm of the specimen and the relation between these factors is interpreted by the decrease of the thickness of the diffusion layer of OH^- and the increase of its diffusion amount.—JSPS. 9559

3.6.6, 6.2.3, 6.3.19

Corrosion of Metals in Alkaline Solutions. Third Rept. On Contact Corrosion of Dissimilar Metals. Part III. Zinc-Mild Steel. H. ENDO AND N. OOTANI. *J. Japan Inst. Metals,* **18,** No. 9, 501-504 (1954) Sept.

Following the previous reports, the galvanic corrosion of zinc in contact with mild steel has been investigated in sodium carbonate and sodium sulfate solutions at 30° and the relation between the potential difference of the metals, the specific resistance of the solutions, polarization and the weight loss ΔW of zinc have been discussed. The tendency of corrosion of zinc is nearly the same as that of mild steel in contact with phosphorus bronze which was shown in the second report. ΔW becomes minimum at pH = 6-7, becomes maximum at pH = 9-11 and decreases to zero at pH>12.5.—JSPS. 9533

3.6.8

Rate of Oxygen Depolarization in the Atmospheric Corrosion of Metals. (In Russian.) I. L. ROZENFEL'D AND K. A. ZHIGALOVA. *Doklady Akad. Nauk SSSR,* **99,** No. 1, 137-140 (1954) Nov. 1.

Relation of copper cathode potential to amount of electricity passed at various relative humidities. Graphs. 9 references.—BTR. 9482

3.6.8, 3.8.4, 6.3.10, 3.4.2

The Process of Electrochemical Evolution of Oxygen on Nickel. (In Russian.) L. M. ELINA, T. I. BORISOVA AND Ts. I. ZALKIND. *J. Phys. Chem. USSR* (Zhur. Fiz. Khim.), **28,** No. 5, 785-790 (1954).

The mechanism of the oxygen overvoltage on a nickel anode was studied by several methods. It was established that the evolution of oxygen takes place on the surface of nickel covered with a

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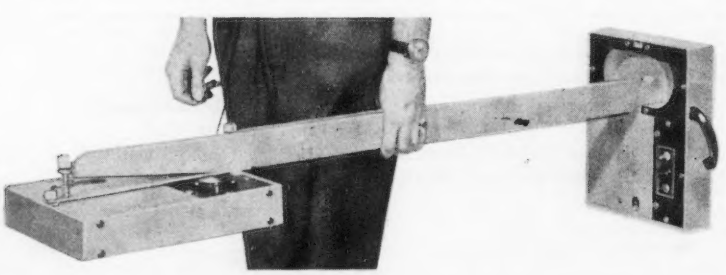

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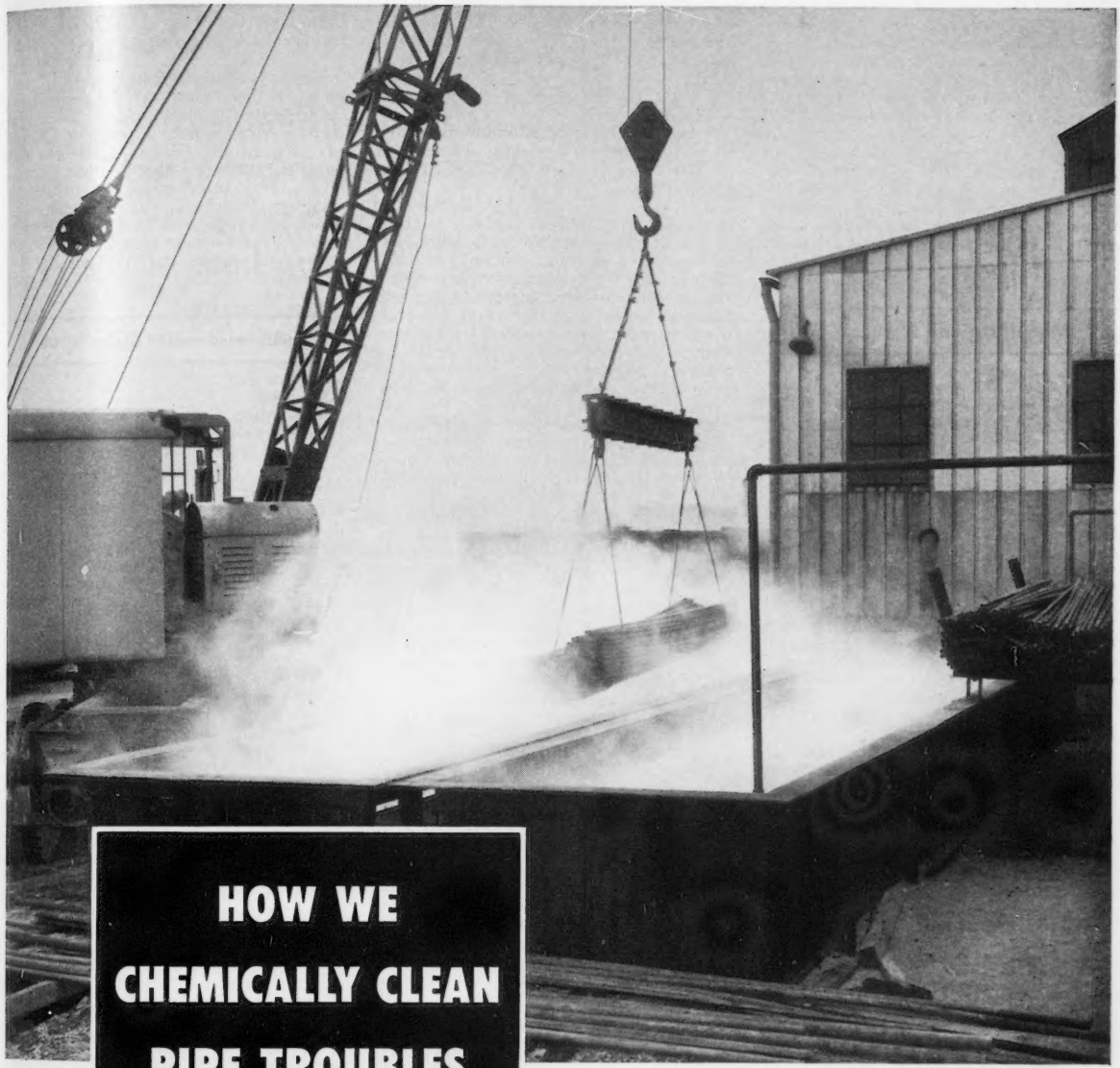

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layer of nickel sesquioxide through the formation and decomposition of a higher oxygenated compound of nickel. At low current density the rate of oxygen evolution is limited by the rate of decomposition of the higher oxygenated nickel compound, at high current density by the rate of its formation as a result of the discharge of OH^-. The results obtained are in full agreement with the catalytic theory of electrode processes which ascribes major importance to the part played by the oxygenated surface compounds in anodic reactions.—MA. 9497

3.7 Metallurgical Effects

3.7.3, 8.8.5

Sub-Zero Heat Treatment. E. H. CLARK. Paper before Australian Inst. Metals, Adelaide Branch. *Australasian Engr.*, **1954**, 121, 123, 125, 127, 129, 131, Oct. 7.

Development of heat treatment practices for Meehanite Castings is reviewed. Hardness required, use of direct water quenching and oil quenching, heating in salt to overcome scale problem, salt quenching to prevent residue in quenching from salt into oil, low temperature salt bath with heat resistant steel on bottom to counter wear and mild steel on top to overcome salt corrosion, and effects of deep freezing on hardness of normal alloy steels are discussed.—INCO. 9496

3.7.3, 6.7.2

Brazing and Grinding of Carbide-Tipped Tools. L. FINE. *Engrs. Digest,* **15,** No. 9, 366-368 (1954) Sept.

Technique and brazing alloys used for joining carbide to steel shanks; grinding and lapping procedures including suitable angles, abrasive material and grit size.—BNF. 9434

3.7.3, 6.4.2

Fusion Welding of Aluminium Alloys. British Welding Research Association. *Brit. Welding J.*, **1,** No. 10, 455-472 (1954) Oct.

The work of the B.W.R.A. in this field concerns metal-arc welding (flux-shielded) of medium strength alloy H.10 (aluminum-magnesium-silicon); welding high-strength heat-treatable alloys by the gas-shielded process; factors in the self-adjusting arc (S.A.A.) process; and problems affecting the process with aluminum-magnesium alloys (N.5/6). The present progress report, which will be followed by five further papers, includes: "Introduction," H. E. Dixon (pp. 455-457; a general statement of the present position of the research) "A Survey of Published Information on the Fusion Welding of Heat Treatable Aluminium Alloys," H. E. Dixon (pp. 458-464). "A Review of Published Information on Weld Cracking in Aluminium Alloys, with Particular Reference to Aluminium-Magnesium-Silicon Alloys", W. G. Hull and D. Adams (pp. 464-467). "Dilution and Uniformity in Aluminium Alloy (Arc) Weld Beads," P. T. Houldcroft (pp. 468-472; investigation shows that in arc welding the weld is thoroughly mixed and of uniform composition, allowing weld-metal composition to be calculated by simple proportion from filler and parent metal composition).—BNF. 9283

3.7.3, 6.4.2

Bonded Joints for (Duralumin) Aircraft Control Rods. D. CLERC AND M. BOGAIEVSKY. *Recherche Aeronaut.*, No. 38, 57-62 (1954) Mar./Apr.; Condensed translation: *Engrs. Digest,* **15,** No. 6, 243-244, 246 (1954) June.

Results of comparative experiments on riveted and bonded joints in control rods are described and it is suggested that the fatigue resistance of bonded joints is greater, on the average, than that of riveted points.—BNF. 9414

3.7.3, 6.3.10

Tentative Specifications for Nickel and Nickel Base Alloy Covered Welding Electrodes. Brochure, 1954, 12 pp. The American Welding Society, 33 West 39th Street, New York 18, N. Y., and American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Penn.

Standard requirements for nickel and nickel base alloy covered welding electrodes for welding nickel and nickel-base alloys individually to themselves and for welding them to steel are listed. Filler metals for welding the clad side of nickel-base alloy clad steels are given.

Twelve classifications of filler metal include nickel, Monel, K Monel, Inconel, Inconel X and various Hastelloy alloys. 9343

3.7.3, 6.2.5

Heat Treatment of Welded Seams of Stainless Steel. (In Russian.) V. V. CHERNYSHEV. *Vestnik Mashinostroeniya,* **34,** No. 8, 83-85 (1954) Aug.

Effects of various heat treatments on corrosion resistance of welded chromium-nickel steels. Photographs, micrographs, table.—BTR. 9506

3.7.3, 6.2.5

Soft Soldering of "Staybrite" and Stainless Steels. Information Letter, Nov., 1954, 1 pp. Issued by Firth-Vickers Stainless Steel Ltd., Staybrite Works, Sheffield 9.

Formula and preparation of recommended flux, zinc chloride/ammonium chloride/hydrochloric acid with 2 percent ferrous sulfate and 2 percent ethylene glycol additions. Flux is claimed to have excellent wetting properties but is corrosive and all traces must be removed by washing. For parts where complete removal cannot be ensured, 50 percent phosphoric acid solution plus 2 percent each of ferrous sulfate and ethylene glycol is suggested.—BNF. 9687

3.8 Miscellaneous Principles

3.8.3, 3.4.8

Activation Potentials of Iron-Chromium Alloys and Their Relationship to the Chemical Stability in Sulfuric Acid. (In German.) HANS-JOACHIM ROCHA AND GUSTAV LENNARTZ. *Arch. Eisenhuttenw.*, **26,** No. 2, 117-123 (1955) Feb.

Dependence of activation potential upon hydrogen-ion activity in sulfuric acid on iron, iron-chromium alloys and chromium; passivity potential in surfuric acid containing air. Graphs, table. 11 references.—MR. 9516

3.8.3, 6.3.8

On the Nature of Lead Surfaces Passivated in Sulfuric Acid. E. J. CASEY AND K. N. CAMPNEY. *J. Electrochem. Soc.*, **102,** 219-225 (1955) May.

Experimental results are presented which show that the rate of ennoblement of the electrochemical potential of lead which is passivating in sulfuric acid is markedly dependent on the concentration of hydrogen peroxide, whether formed by irradiation or added directly to the system. A study of factors which affect the ennobled potential of the sulfated or passivated lead is presented, as is a study of the conditions under which the sulfated lead shows rectifying properties. Results are interpreted in terms of the suggested presence of oxygen atoms sorbed into the lead sulfate layer. 9335

3.8.3

Mechanism of Self-Passivation of Metals in Oxidizing Media. (In Russian). V. P. BATRAKOV. *Doklady Akad. Nauk SSSR,* **99,** No. 5, 797-800 (1954) Dec. 11.

Presents an expanded electrochemical treatment; discusses the relative importance of various factors. Graphs. 6 references.—BTR. 9334

3.8.3, 3.6.8

Mechanism of the Overpassivation of Steels in Oxidizing Media. (In Russian). V. P. BATRAKOV. *Doklady Akad. Nauk SSSR.* **99,** No. 1, 97-100 (1954) Nov. 1.

Anodic and cathodic polarization. Mathematical formulas. Graphs. Eight references.—BTR. 9360

3.8.3, 3.8.4, 6.2.2

The Electrical Field Within the Passive Film on Iron. KLAUS J. VETTER. *Z. Elektrochem.*, **58,** No. 4, 230-237 (1954); Translation by F. Hudswell, Atomic Energy Comm. Pubn., AERE-Lib/Trans-449, 13 pp.

The existence of a potential difference within a passive noncorroding film on iron has been confirmed. The potential difference is of the order of magnitude of 1 volt and causes the migration of ions through the film as indicated by the dc conductivity of the film. The investi-

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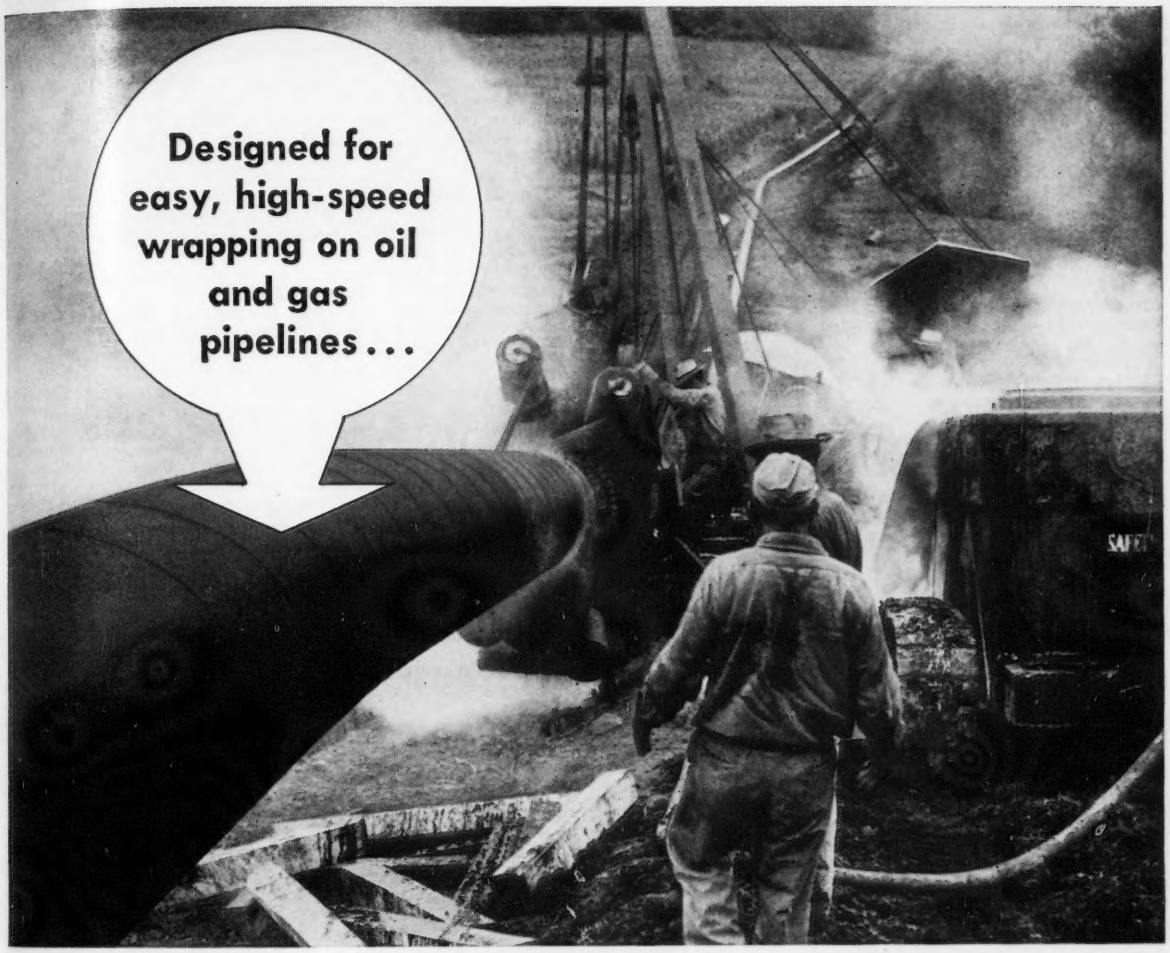

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gations confirming these results are described.—NSA. 9485

3.8.3, 6.2.2.

Anodic Passivation of Iron in Concentrated Sulfuric Acid. (In Russian.) V. M. Novakovskii and A. I. Levin. *Doklady Akad. Nauk SSSR,* **99,** No. 1, 129-132 (1954) Nov. 1.

Effects of acid concentration and current density on passivation behavior. Diagram, graphs. 9 references.—MR. 9556

3.8.3, 6.2.5

Passivity Phenomena in Stainless Steels. (In Italian.) A. Ferri. *Metallurgia italiana,* **46,** special supplement to No. 5, 33 (1954) May.

Measurement of electrochemical potential in 1-N sulfuric acid, at 30°C, of 18/8 stainless steel. Tables. 2 references.—BTR. 9446

3.8.3, 6.3.19

Passivity of Zinc in Relation to Conditions of Aeration. (In Italian.) G. Bianchi. *Metallurgia italiana,* **46,** special supplement to No. 5, 29-30; disc., 30 (1954) May.

Zinc in a solution of sodium chloride is considered in study of corrosion by galvanic macro-elements. Charts.—BTR. 9508

3.8.4

Rate Constant of the Reaction Between Hydrogen Peroxide and Ferrous Ions. T. Rigg, W. Taylor and J. Weiss. *J. Chem. Phys.,* **22,** No. 4, 575-577 (1954).

Spectrophotometric determination of the rate constant of the reaction between hydrogen peroxide and ferrous ions shows that the rate is independent of pH (between 0.05N and 0.8N sulfuric acid) and is bimolecular. $k = 1.05 \times 10^8 \times e^{(-8460/RT)}$/moles.$^{-1}$ sec.$^{-1}$—EL. 9332

3.8.4

The Surface Energy of Solids. (In German). Rudolf Auerbach. *Werkstoffe u. Korrosion,* **5,** No. 6, 208-212 (1954).

A general review is given of ideas of surface tension, with particular reference to solid surface tension and the various relations which have been developed between surface tension and other physicochemical properties, such as heat of sublimation, lattice constant elastic moduli, parachor, etc. Values for solid surface tension at room temperature, of metals (in dynes/cm.), as derived from different sources, are given. Graphs show the change of solid surface tension with composition for the systems iron-chromium and iron-nickel. Values of solid surface tension are also given for some non-metallic substances, and some values are given for the surface tension of molten metals. The lack of agreement among the values indicates the need for further work. 14 ref.—MA. 9347

3.8.4, 1.6, 6.2.5, 3.2.3, 3.5.9

Investigations of the Oxidation of Chromium and Nickel-Chromium Steels. Summary Technical Report. H. J. Yearian. Purdue Univ., June, 1954, 98 pp.

The structures of the oxide scales formed on commercial chromium steels containing 5 to 26 percent chromium when oxidized in air or oxygen at temperatures from 700°C to 1160°C for times up to 100 hrs., have been determined by X-ray diffraction methods, assisted in some instances by chemical analysis. Two distinct types of scale are observed: A-type scale occurs when the rate of metal loss is less than approximately 10 mg/cm^2/day and B type when the attack rate is in the excessive range. For exposures near the critical conditions an initial A-type scale transforms to B type during oxidation. The essential component of A-type scale is chromic oxide. This is usually accompanied by α ferric oxide in an amount which increases with the iron content of the alloy, i.e., with rate of attack; at high temperatures or long oxidation times, dilute solid solutions of each of these phases in the other are formed. When the alloy contains a few-tenths percent of manganese, the A-type scale may also include copious amounts of manganese chromite, especially for high-chrome alloys and for low-temperature oxidations in air. The structure of the scale formed on nickel-chromium steels ranging from 8 to 80 percent nickel and 0 to 26 percent chromium when oxidized for 100 hours in air at temperatures from 1600 to 2200°F have also been investigated by X-ray diffraction. The scales are again of two types, A′ and B′, which are analogous to and show the same correlations with attack rate as the A and B scales, respectively, on chromium steels. (auth).—NSA. 9455

3.8.4, 3.2.3, 3.8.3

Initial Corrosion of Metals in Contact with Aqueous Solutions at Room Temperature. F. Todt. *Werkstoffe und Korrosion,* **5,** No. 11, 430-433 (1954) Nov.

Hydrogen corrosion and oxygen corrosion characteristics and the initial phenomena connected therewith are discussed. Rapid initial corrosion followed by decrease in corrosion rate. Supporting data on rate of solution of aluminum as affected by degree of purity, and maximum rate of corrosion of iron and factors affecting it are given. Protective layers, their formation and destruction, with reference to nickel-chromium stainless steels are described. Tables, 10 references.—INCO. 9526

3.8.4, 3.2.3, 6.3.11

Optical Study and Continuous Recording of the Corrosion of Silver by Iodine Vapor. (In French). Georges Colange and Rene Dubrisay. *Compt. rend.,* **239,** No. 23, 1629-1631 (1954) Dec. 8.

Hypothesis concerning the difference between the first and the subsequently formed corrosion rings. Photographs. 4 references.—BTR. 9412

3.8.4, 3.2.3, 6.3.6

Study of Metallic Oxidation by Change of Weight. Part IV. Copper-Zinc Alloys. (In Italian). N. Collari and P. Spinedi. *Metallurgia italiana,* **46,** No. 11, 403-409 (1954) Nov.

The authors examined the behavior of several copper-zinc alloys by the isothermal research method (curves of weight-time increase), and for some concentrations they also applied, at the same time, the method of directly tracing the curves plotting oxidation against temperature.

The aim of these researches has mainly been to point out the relationship which may occur between the oxidizability of the alloys being examined and their composition. It has been possible, particularly, to ascertain that the influence of incidental superlattices, originated in correspondence to well-determined atomic ratios among the alloy's components, is the deciding factor for the form of the curves plotting oxidation against composition.

This occurrence is particularly significant in the case of the solid solution α (containing the superlattice Cu_3Zn) and of the solution Υ (containing the Cu_5Zn_8). Finally an attempt has been made to explain this particular behavior according to the up-to-date points of view of the science of metals.—MI. 9413

3.8.4, 3.5.8

Kinetics of Formation of Porous or Partially Detached Scales. Metallurgy Report No. 1. C. E. Birchenall. Forrestal Research Center, Princeton Univ., July, 1954, 11 pp.

The variety of kinetic relations which may be found for the oxidation of solid

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metals when porosity forms in the oxide or at the metal-oxide interface according to several systematic procedures is examined. Particular attention is given to the time sequence in which various rate laws may govern the process. The need for more careful correlation of microstructures with rate measurements is emphasized. The possible role of plastic deformation is also considered. (auth).—NSA. 9537

3.8.4, 3.6.5

Residual Currents. E. NEWBERY. *Trans. Roy. Soc. S. Africa,* **34,** 25-41 (1954).

A potential difference, increasing and decreasing at intervals of 1 min in 0.1 v steps up to 1.0 v (i.e., below the decomposition potential of the electrolyte) and back to zero, was applied between two unattackable electrodes, and the resulting residual currents were observed. The electrodes were either bright or platinized platinum, or bright gold. The electrolyte was 5N sulfuric acid, 5N hydrochloric acid, or M cupric sulfate. In all instances the current was high at first at each change of potential difference (20-100 microamperes) and then dropped quickly to 50-80 percent lower values, which subsequently diminished slightly. Definite ageing effects of bright platinum electrodes were shown. The presence of free oxygen in solution was without effect; dissolved hydrogen had a marked but poorly reproducible effect. There also was a marked but variable effect when the electrodes were shaken or on stirring, unless a metal tended to deposit. Usually over 80 percent of the total residual current was not recoverable, and only a small fraction of this could be accounted for. Hence about 75 percent of the residual current was carried by some process which did not conform with Faraday's laws. A possible mechanism is suggested.—EL. 9563

3.8.4, 3.6.8

Depolarization Effects After Current Reversal at Silver Anodes and Cathodes. A. L. FERGUSON AND D. R. TURNER. *J. Electrochem. Soc.,* **101,** No. 7, 382-386 (1954).

Anode and cathode reactions at silver electrodes in hydrogen-saturated 2N-sulfuric acid after current reversal were studied by recording potential/time curves. Three anodic processes occur when the current is reversed from cathode to anode: a) ionization of adsorbed hydrogen atoms; b) oxidation of absorbed hydrogen; c) dissolution of silver. After current reversal from anode to cathode, three cathode reactions occur; i) reduction of the silver sulfate film; ii) discharge of hydrogen ions into absorption and adsorption positions in the silver electrode; and iii) discharge of hydrogen ions and formation of molecular hydrogen. 19 references.—MA. 9511

3.8.4, 3.7.4, 3.5.9

Influence of the Crystalline Orientation of Iron on the Formation of Oxide Nuclei at Its Surface at Low Oxygen Pressures and High Temperatures. (In French). JEAN BARDOLLE AND JACQUES BENARD. *Compt. rend,* **239,** No. 12, 706-709 (1954) Sept. 20.

Quantitative study on oxidation mechanism. Diagram, micrographs. Four references.—BTR. 9364

3.8.4, 4.6.11

Sea Water Corrosion of Steel Pieces. (In French). G. DECHAUX AND E. SEGOL. *Metaux, Corrosion-Industries,* **29,** No. 352, 469-482 (1954) Dec.; *Bull. Assoc. Tech. Marit., Fr.,* No. 53, 101-120 (1954).

Experimental data on the functioning of corrosion cells in an alkaline and aerated medium. Photographs, micrographs, graphs.—BTR. 9468

3.8.4, 5.4.5

Nature of Adhesion. F. W. REINHART. *J. Chem. Educ.,* **31,** No. 3, 128-132 (1954); *P.R.S. Rev.,* **27,** No. 160, 419 (1954) July-Aug.

Adhesion is mainly due to van der Waals forces, and to a lesser degree to primary valence forces, though in no case does the measured adhesion attain the magnitude predicted by theoretical consideration of these forces. This deficiency is due first to incomplete wetting of the adherent by the adhesive and secondly to physical changes in the adhesive on hardening.—EL. 9459

3.8.4, 6.2.1, 3.5.12

The Microscopic Forms of Iron Rust. Part IV. (In German.) ADOLF ACKERMANN. *Kolloid Z.,* **137,** 20-24 (1954) June.

Sheet iron samples 3 by 2 by 0.012 cm, were immersed in distilled water for 12-24 hr. Microphotographs are presented to show that the patterns of rust deposition correspond to the lines of a magnetic field, in which the observed corrosion craters are situated at the poles. Such poles are induced in highly paramagnetic ferritic grain structures by the magnetic field of the earth. Where ferrite grains cannot form, as in finely grained razor blades, corrosion craters are not observed. Similarly, if a stronger magnetic field is induced by a magnet outside the beaker containing the sam-

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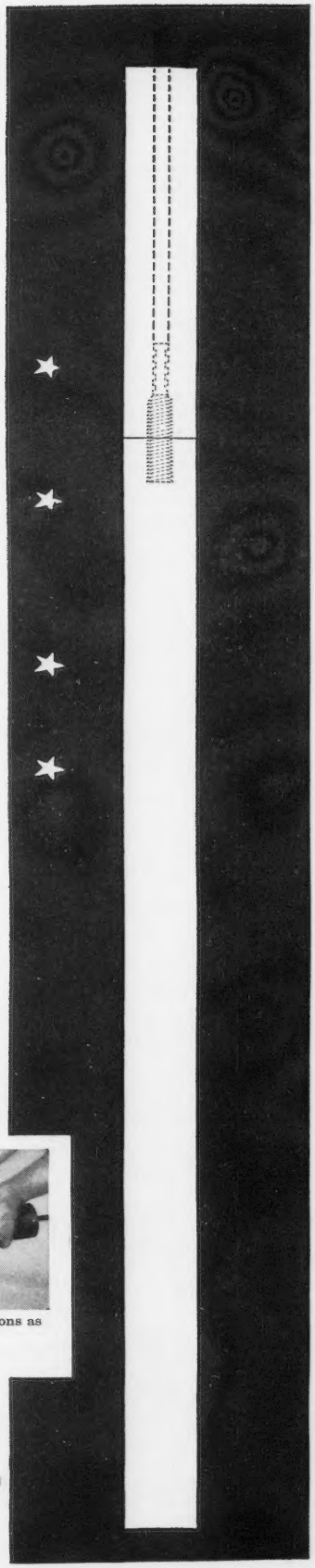

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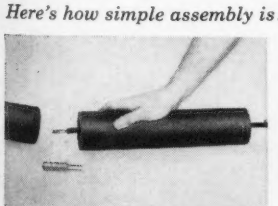

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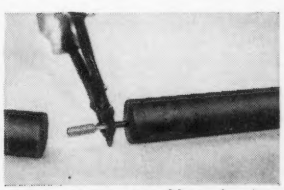

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ple, the craters attributed to the earth magnetic field are replaced by rust deposits at the ends of the sheet where the force lines of the stronger magnet enter and leave the sample.

Further evidence for the magnetic corrosion theory includes the known fact that steels showing no permanent magnetism, such as chromium-nickel or manganese steels, do not rust. Accordingly, any ferrous material, from the softest wrought iron to the hardest steel, should become immune to corrosion attack if it can be prevented from emitting magnetic force lines. In an experiment in which the immersed sheet-iron sample was demagnetized by attaching it to a vibrator running at 50 cycles per sec., no signs of corrosion were detected up to seven days, regardless of the mode of immersion, but the characteristic rust craters formed within 24 hr. after the vibrator was disconnected. If this pattern of rusting were caused by an electrochemical effect, vibration would have been without influence. At hydrogen-ion concentrations higher than that of distilled water, the magnetic mechanism is, however, obscured by the stronger chemical or electrolytic oxidation of iron, which is further increased by vibrating the test specimen.—PDA. 9454

3.8.4, 6.3.11

Mechanism and Rate-Controlling Factors in the Dissolution of Gold in Cyanide Solution. V. KUDRYK AND H. H. KELLOGG. *J. Metals* (Trans. AIME), **6,** No. 5, 541-548 (1954).

A report of a study of the factors which control the rate of dissolution of pure gold (99.99+ percent in cyanide solution. The mechanism of dissolution is probably electrochemical in nature. The rate is controlled either by the rate of diffusion of oxygen or CN^- to the gold surface; for solution in equilibrium with air (21 percent oxygen) at 27°C, the rate is controlled by the rate of oxygen diffusion if the cyanide concentration is >0.0175 percent potassium cyanide, and by the rate of CN^- diffusion for concentration <0.0175 percent potassium cyanide. The rate of dissolution can be increased by the usual factors which increase diffusion rates, viz. increased agitation, increased concentration of the diffusion-limited reactant, and increased temperature (but the solubility of oxygen decreases with increase in temperature). The product of reduction of oxygen is OH^-; peroxide, if it forms at all, must be quickly reduced to OH^-. The industrial significance of the results is considered, and the effects of impurities are discussed. 14 references.—MA. 9471

3.8.4, 6.3.15, 3.2.3, 3.2.2

Diffusion of Nitrogen and Oxygen in Titanium. R. J. WASILEWSKI AND G. L. KEHL. Columbia Univ. *J. Inst. Metals,* **83,** No. 3, 94-104 (1954) Nov.

The diffusion rates in massive β-titanium, and their temperature dependence, have been determined for nitrogen in the range 900 to 1570°C and for oxygen in the range 950 to 1414°C, assuming D to be independent of the solute concentration. This appears probable in the case of nitrogen throughout the solubility range in β-titanium; diffusion rates for oxygen, however, appear to decrease at higher solute concentrations. A mathematical analysis has been carried out to account for the initial deviation from the parabolic rate law in gas/metal reactions. An approximately linear reaction rate has been derived from short reaction times. The case of diffusion with simultaneous formation and growth of a thin surface layer has also been analyzed. An expression has been derived permitting approximate calculation of the diffusion coefficient of the solute in the surface layer from obtainable experimental data, when the layer is too thin for experimental determination of the concentration distribution. This analysis was used to evaluate the diffusion coefficients of nitrogen in α-titanium and titanium nitride between 900 and 1570°C. (auth).—NSA. 9557

3.8.4, 6.3.20, 6.3.15, 3.2.3

Investigation of the Absorbent Properties of Non-Powdered Gas Absorbers. (In Russian.) E. LYUBOVSKAYA AND A. RAVDEL. *J. Technical Physics USSR* (Zhur. Tekh. Fiz.), **24,** 1393-1400 (1954) Aug.

The temperature dependence of the absorption capacity of zirconium and titanium-thorium alloys for hydrogen and oxygen was determined. A comparatively narrow range of absorption was found for hydrogen on ziconium at 500°C, but increasing amounts of oxygen were absorbed starting at 400°C. Some hydrogen absorbs at room temperature. The range of absorption of hydrogen on titanium-thorium varies from 400 to 600°C, and practically none is absorbed at room temperature. Intensive absorption of oxygen begins at 500°C and increases with further increase of temperature. The absorption capacity of titanium-thorium for hydrogen is approximately twice as large as that of zirconium, but zirconium has a correspondingly higher capacity for oxygen than titanium-thorium.—NSA. 9567

3.8.4, 6.3.20, 1.6

Corrosion of Zirconium. II. A Reaction Rate Study of the Solution of Hafnium-Free Zirconium in Hydrofluoric Acid Solutions. Technical Report No. XVI. TENNYSON SMITH AND GEORGE RICHARD HILL. Institute for the Study of Rate Processes, Univ. of Utah. U. S. Atomic Energy Comm. Pubn., AECU-3002, Nov. 30, 1954, 52 pp.

The rate of solution of zirconium in hydrofluoric acid solutions is being studied using a radioactive tracer Zr^{95}. By an appropriately designed system, continuous records of the rate are possible. The rate has proven to be dependent on the hydrofluoric acid concentration except at low H^+ concentrations—this is being investigated further. Four possible mechanisms for the slow step in the reaction are suggested, two of which are considered to be more likely. Further work will allow differentiation between these two. They were the adsorption of hydrofluoric free acid on the surface and the reaction of zirconium with hydrofluoric acid adsorbed, with some substance adsorbed on the surface, probably oxygen. The products of the reactions were shown to be mostly ZrF_3^+ ion in solution and hydrogen and nitrogen monoxide in the gas phase depending on whether hydrochloric acid or nitric acid was in solution with hydrofluoric acid. Oxygen was also detected as a gaseous product. An Arrhenius plot yielded an activation energy of 4.0 kcal/mole for the rate determining step. (auth).—NSA. 9379

3.8.4, 6.3.21

Reaction of Thallium With Oxygen and Moisture. J. T. WABER AND G. E. STURDY. *J. Electrochem. Soc.,* **101,** 583-589 (1954) Dec.

Investigations in the range 25-75°C to throw light on mechanism of atmospheric corrosion. X-ray diffraction confirms principal reaction product changes from thallous oxide to thallous hydroxide. Graphs, tables. Thirteen references.—BTR. 9384

3.8.4, 6.3.6

The Kinetics of the Corrosion of Copper in Acid Solutions. JOHN RANDEL WEEKS AND GEORGE RICHARD HILL. Institute for the Study of Rate Processes, Univ. of Utah. U. S. Atomic Energy Comm. Pubn., AECU-2992, Dec. 15, 1954, 21 pp.

The corrosion mechanism of copper in dilute hydrochloric acid solutions was investigated, and data are presented on the effects of time, pH, concentration of dissolved oxygen, and temperature on the corrosion mechanism.—NSA. 9386

3.8.4, 6.3.6, 3.6.8

Mechanism of Anodic Attack of Copper. (In French). RENE AUDUBERT. *Compt. rend.,* **239,** No. 25, 1792-1795 (1954) Dec. 20.

Kinetic theory of overvoltage makes it possible to explain the mechanism of anodic dissolution of copper in an acid medium. Graphs. Two references.—BTR. 9348

3.8.4, 6.4.4.

Electron-Diffraction Investigation of Thin Films of Magnesium-Antimony, Magnesium-Bismuth, and Magnesium-Tin Alloys. (In Russian.) G. A. KUROV AND Z. G. PINSKER. *Doklady Akad. Nauk S.S.S.R.,* **94,** No. 3, 439-441 (1954).

The transparent bands discovered in thin films of continuously varying composition of magnesium-antimony, magnesium-bismuth, and magnesium-tin alloys (cf. *ibid.,* No. 2, 207) were studied by electron-diffraction methods. Analysis of the electronographs obtained showed that the alloys in the region corresponding to Mg_3Sb_2, Mg_3Bi_2, and Mg_2Sn were composed of magnesium oxide and antimony, bismuth, or tin, respectively. The oxidation of magnesium was quicker and more complete after deposition of mixed vapors in vacuum than of pure magnesium under similar conditions. The behavior of magnesium atoms in Mg_3Bi_2, Mg_3Sb_2, and Mg_2Sn in respect of the rate of oxidation and diffusion through the magnesium oxide layer indicated that these phases were not true chemical compounds in spite of their stoichiometric composition, but that they belonged to an intermediate class between chemical compounds and solid solutions.—MA. 9463

3.8.4

Diffusion and Oxidation of Solid Metals. C. E. BIRCHENALL. *Ind. and Eng. Chem.,* **47,** 604-613 (1955) Mar.

This review includes references on diffusion (volume diffusion of substitutional alloys, Kirkendall effect, diffusion in interstitial alloys, grain-boundary and surface diffusion, diffusion in germanium and silicon, and oxidation (reviews, properties of oxides and related crystals, oxidation of pure metals, oxidation of alloys). 135 references.—NSA. 9431

3.8.4, 3.2.3

The Interaction of Oxygen with Clean Metal Surfaces. M. A. H. LANYON AND B. M. W. TRAPNELL. Univ. of Oxford. *Proc. Roy. Soc.* (London), **A227,** 387-399 (1955) Jan. 20.

Isobars for the adsorption of oxygen, hydrogen, and carbon monoxide on evap-

orated films of rhodium, molybdenum, tungsten and iron, of oxygen and carbon monoxide on tantalum, platinum, and palladium, and of oxygen on copper, aluminum, and zinc have been obtained. On rhodium, molybdenum, and tungsten the rapid adsorption of oxygen and hydrogen at —183° C. results in formation of monolayers with one atom per surface atom. On tantalum, platinum, palladium, copper, aluminum, and zinc, oxygen, and on iron, hydrogen, form similar monolayers, but on iron oxygen forms several layers of oxide. On rhodium, molybdenum, and possibly tantalum the fast carbon monoxide chemisorption corresponds to a two-site mechanism; on tungsten and iron it lies between that for a single and a two-site mechanism; on platinum and palladium single-site adsorption may take place. Kinetics of slow oxygen uptake have been followed on rhodium, molybdenum, tungsten, tantalum, iron, copper, and zinc. With rhodium, molybdenum, tungsten, tantalum, and zinc it is believed that formation of the first oxide layer has been observed, and the rate expression is given. The suggested mechanism is interchange of adsorbed oxygen atoms with underlying metal atoms, whereby metal atoms are exposed for further oxygen adsorption. On copper and iron formation of up to six and ten oxide layers respectively have been observed, and the rate expressions have been interpreted in terms of the theory of Cabrera & Mott (1948). (auth). —NSA. 9449

3.8.4, 3.4.3

Solid Products of Corrosion as Corrosion-Governing Elements. (In German.) W. FEITKNECHT. *Werkstoffe und Korrosion,* **6,** No. 1, 15-26 (1955) Jan.

Detailed results show manner in which the solid products govern the whole corrosion process according to their constitution, formation, and dispersal. Micrographs, tables, graphs, diagrams, X-ray diagram. 26 references.—BTR. 9534

3.8.4, 3.7.4, 3.2.3

Principles Applicable to the Oxidation and Corrosion of Metals and Alloys. W. W. SMELTZER. *Corrosion,* **11,** No. 9, 366t-374t (1955) Sept.

Phenomenological basis of kinetic laws governing oxidation is described to illustrate manner of growth and protective properties of oxide films on metals. Metals are separated into groups forming "metal-excess" and "metal-deficit" oxide films and emphasis is placed on role of lattice defects in governing diffusion of metal through film to react with environment. Effects of alloying elements on oxidation rates of metals are discussed in terms of formation of films consisting of heterogeneous mixtures and solid solutions of oxides and intramolecular oxides. Special reference is made to aluminum and its alloys for illustrative examples. 13 figures, 59 references. 9542

4. CORROSIVE ENVIRONMENTS

4.3 Chemicals, Inorganic

4.3.2, 6.2.2, 8.8.1

The Corrosion of Iron in Nitrose. Part I. Corrosion in Sulfuric Acid Solution. Part II. Corrosion Mechanism in Sulfuric Acid Solutions. H. ENDO AND G.

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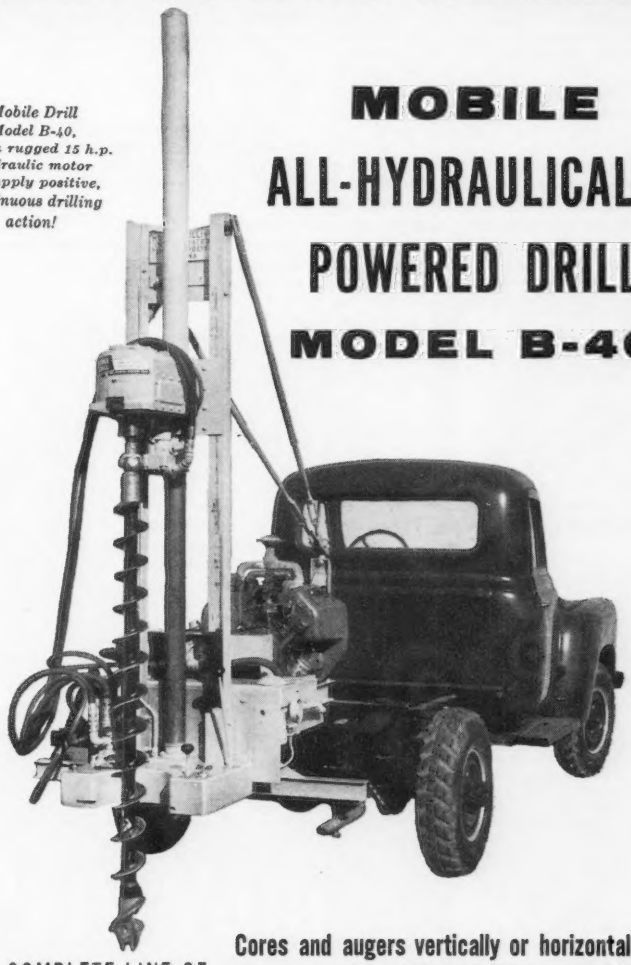

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YOKOHAMA. *J. Japan Inst. Metals*, **18**, No. 1, 11-14, 14-18 (1954) Jan.

Part I. Research for the corrosion of iron in sulfuric acid manufacturing plant (tower system) was projected. In this paper the corrosion in 50~ 90 percent sulfuric acid solutions without nitrogen oxide is reported. Iron can be employed in conditions below 40°C temperature and above 60 percent concentration of sulfuric acid.

Part II. Corrosion of iron in 50 percent sulfuric acid solution shows the similar reaction as in more dilute acid solution. In the acid solution above 60 percent concentration, corrosion mechanism is different from the one below 50 percent. Sulfate ions are reduced to sulfite and sulfide ions on the iron surface, and the sulfide ions combine with ferrous ions, forming a ferrous sulfide protective film on iron. The sulfide film is dissolved very slowly and is replaced by ferrous sulfate.—JSPS. 9527

4.3.3, 3.5.8, 6.2.5, 6.2.3

Corrosion of Steels by Hot Alkaline Solutions Under Pressure. (In Russian.) KH. L. TSEITLIN, N. K. KURCHENINOVA, S. M. BABITSKAIA, AND A. A. BABAKOV. *Chemical Industry* (Khimicheskaia Promyshlennost), No. 7, 438-440 (1954) Oct.-Nov.

Stainless steels in the unstressed state are more resistant to corrosion but are less resistant to formation of cracks than the low-carbon steels in stressed state. Tables.—BTR. 9522

4.4 Chemicals, Organic

4.4.7, 5.8.2

Applying Lube-Oil Additives. Parts II, III, IV. W. D. THOMAS. Am. Cyanamid Co. Paper before W.P.R.A. Mtg. *Oil Gas J.*; **52**; Nos. 39, 40, 41; 97, 147, 187 (1954) Feb. 1, Feb. 8, Feb. 15.

Individual additives discussed include inhibitors combining phosphorus and sulfur in oil-soluble organic compounds, detergent additives such as sulfonates, phenates and silicon oils, and rust preventives. Modern motor oils and their formulations are considered. Author states that test methods are required for the development of new and improved products and for quality control. Comments on applying lube-oil additives are given by V. A. Kalichevsky. Illustrations, 4 references.—INCO. 9394

4.4.7, 8.8.5

Cutting Fluids and Corrosion. Effects of Soluble Cutting Oils on Machine Tool Surfaces. Extract from "Properties of **Soluble Cutting Oils,"** pub. by Production Engineering Research Assoc., Great Britain. *Corrosion Technology*, **1**, No. 5, 153-158 (1954) July.

Way in which the oils have been mixed; whether metal chips have been left on the machine tool surfaces; whether the surfaces have been greased; these and other factors have an important bearing on the corrosive effect of soluble oils. Tests carried out by the PERA on 11 soluble oils are described and the data obtained, together with the conclusions and recommendations of the investigators, are presented. Tables and charts.—INCO. 9513

4.5 Soil

4.5.1

Fundamentals of Underground Corrosion. F. E. COSTANZO. (Paper, Am. Gas Assoc. Eng. Conf., Pittsburgh, May 24, 1954; *Gas Age*, **114**, No. 2, 49-54, 78, 80 (1954) July.

The fundamentals of corrosion of underground plant structures are reviewed with emphasis on interpreting measurements of electrical potentials, currents and resistance.

4.5.1, 3.4.9

The Influence of Soil Moisture on the Corrosion Rate of Buried Iron and Lead. (In German.) THOMIL MARKOVIC. *Werkstoffe u. Korrosion*, **5**, No. 7, 244-246 (1954) July.

Corrosion in wet soils was followed by measuring the current from the cell platinum | soil | base-metal for different degrees of soil saturation. It was found that the relation $\log V = 1 + 0.25 \log i$ was obeyed up to 33 percent moisture, where V = percent moisture in soil and i = current in μ amp. For the cell platinum | soil | iron, current/time curves of two different forms were obtained. Oversaturated soil produced an initially high current which fell to a permanently low value as in electrolytes (passive behavior), but unsaturated soil led to a current curve which rose again after the initial fall (active behavior). The mechanism of this active behavior is discussed in relation to oxygen diffusion and the formation of the new cell: platinum | soil | hydrated ferric oxide. Lead and zinc are passive in wet soils whatever the moisture content and behave as they do in electrolytes.—MA. 9571

4.6 Water and Steam

4.6.1, 1.6

Corrosion of Metals in High Temperature Water at 500°F. and 600°F. S. C. DATSKO. U. S. Atomic Energy Comm. Report, ANL-5354, Oct. 4, 1954, 203 pp.

The corrosive nature of water at 2000 psi to a number of metals including zirconium and zirconium alloys, AISI 300 series stainless steels, hardened 400 series stainless steels, nitrided or Malcomized steels, welded and Nicrobrazed joints, A-Ni, 70-30 copper-nickel, Inconel, Monel, palladium alloys, and titanium was investigated. Experimental conditions included water temperatures of 500 and 600°F; dissolved solid content of the water—initially deionized with no corrosion product removal, continuously deionized, and with sodium hydroxide additions; and gas content of the water—degassed, with oxygen additions, and with hydrogen additions. The austenitic stainless steels of the 300 series and certain types of zirconium showed the best corrosion resistance in water. The corrosion of the nickel and copper-nickel alloys increased as the oxygen content increased. Corrosion in 500°F water containing at least 50 cc. of hydrogen was minor. Operation of the system at 500°F with water containing at least 50 cc of hydrogen per liter permits the widest selection of materials. Testing apparatus and procedures are described and experimental data are tabulated. Illustrations, photomicrographs, 98 tables, 41 references.—INCO. 9467

4.6.1

Report on Performance of Materials Tested in Water at High Temperature. C. J. LANCASTER. U. S. Naval Engineering Experiment Station Rept., EES-4A(16)-966870, 12 pp., 1952; unclassified, 1954 (on micro-cards).

Results are presented for 30-day dynamic corrosion tests on twelve materials; the samples were subjected to a static bending stress while rotating at a peripheral velocity of 11 ft/sec in oxygenated water at 500°F (260°C). Appearance and weight losses were recorded. The materials studied included: 90:10 and 70:30 copper-nickel alloys, a number of chromium alloyed iron and stainless steels, gold plating and brazing on stainless steel, and an iron alloy containing nickel 25, chromium 17, and molybdenum 5 percent. The weight changes in the copper-nickel alloys and in the brazing metal were such as to preclude their use under these conditions.—MA. 9523

4.6.1, 3.5.11

Corrosion Tests on Sixteen Materials in 500°F. (260°C.) Water at High and Low Velocities. C. J. LANCASTER. U. S. Naval Engineering Experiment Station Rept., 1952, EES-4A(21)-966870, 21 pp., unclassified, 1954 (on micro-cards).

Results are presented of corrosion tests on sixteen materials exposed to water at 500°F (260°C) with flow velocities of 10 ft./sec. and 1 ft./hr., the water containing 20-30 cc oxygen/l. The high velocity tests were carried on for 90 days and the low-velocity ones for 60 days. The materials tested included Inconel, Monel, K-Monel (age-hardened and annealed), A-Ni, 70:30 copper-nickel alloy, and a number of stainless steels. The austenitic steels showed a superior performance to the other materials at high velocities and also at low velocities provided that contact conditions were avoided. The susceptibility of Monel A-Ni, and K-Monel to pitting at both velocities made their application in these conditions doubtful. The corrosion-rate of the copper-nickel alloy was high in both cases, but the corrosion loss was generally distributed. 4 references.—MA. 9521

4.6.1, 5.8.2

Treatment of Disassembly Basin Water. F. A. LOCKE. E. I. DuPont de Nemours and Co. Explosives Dept., Atomic Energy Div. U. S. Atomic Energy Comm. Pubn., DP-81, Oct., 1954, 14 pp.

Corrosion of steel piping and basin equipment was found to be the main cause of the deposition of a brown flocculent material on the floor and walls of a pile disassembly basin. A combination of sodium dichromate and chloramine, the best of seven water treatments tested, reduced steel corrosion 50 percent, zinc corrosion 80 percent, and met the standards for control of turbidity and bacteria in the water of the basin. (auth).—NSA. 9560

4.6.11, 2.2.7

Preliminary Report on Corrosion of Some Common Metals in Sea and Creek Water. H. R. AMBLER. Gt. Brit. Tropical Testing Establishment, Port Harcourt, Nigeria, Report No. 335, March, 1954, 4 pp.

Preliminary results are given on the corrosion of sheet samples of sand-blasted mild steel, brass, and aluminum immersed in tropical waters at Lagos Harbor (0.22-3.00 percent salinity, pH 7.2-8.0, temperature 25.5-29°C), and at Port Harcourt Creek (1.3-2.08 percent salinity, pH 7.2-8.0, temperature 27-29.5°C). In addition, laboratory exposures were made in static and aerated creek water, static and aerated distilled water, and static boiled distilled water.

Corrosion of mild steel was high, up to 70 mil per yr. It corroded most on

tidal immersion and less than half as much under total immersion. Brass, however, corroded much more on total than on tidal immersion. Aluminum showed no regular effect. Corrosion in the laboratory with creek water, aerated or static, was much less, particularly for brass, than in the actual creek exosure, suggesting the influence of biological factors. A mild steel panel totally immersed at Port Harcourt for 2½ months and subsequently placed in dilute acid, produced a strong smell of hydrogen sulfide, suggesting activity by sulfate-reducing bacteria. A similar panel, examined after 2 weeks exposure, produced no detectable hydrogen sulfide. Aerated distilled water was as corrosive under laboratory conditions as was creek water for steel, but not for brass.—PDA. 9315

4.7 Molten Metals

4.7

Thermal and Related Physical Properties of Molten Materials. Progress Report No. 11, for Period Aug. 1-Oct. 31, 1954. B. E. WALKER, CURTIS T. EWING, AND D. D. WILLIAMS. Naval Research Lab,. Memo. 393, Dec. 17, 1954, 9 pp.

Heat content measurements were made on Monel salt containers from 100 to 900°C and the fused salt from 100 to 580°C with heat capacity values of the salt from 64 to 354°C. The reactions of fused sodium hydroxide with Monel and Cu are discussed, and equations are given. Equations for the reaction of fused sodium hydroxide with iron, titanium, tantalum, beryllium, manganese, and chromium are also given.—NSA. 9564

4.7, 6.3.10

Kinetic Study of Mass Transfer by Sodium Hydroxide in Nickel Under Free-Convection Conditions. DON R. MOSHER AND ROBERT A. LAD. U. S. Nat'l. Advisory Comm. for Aeronautics, Research Memo., March 10, 1954, 14 pp. (E53K24).

Specimens of "L" nickel were tested in molten sodium hydroxide under free-convection conditions at 1000°-1600°F (540°-870°C). Specimen weight loss in the hot zone had an almost linear relation to the weight of nickel deposited in the cool zone. The nickel concentration in the melt approached an equilibrium value after 100 hours. The rate of mass transfer was very sensitive to temperature and tempearture gradient, and reached an equilibrium value after 30 hours.—MA. 9531

5. PREVENTIVE MEASURES

5.2 Cathodic Protection

5.2.2

Galvanic Anodes Control Induced Voltages on Pipe Lines. Topic of the Month. E. H. THALMANN. *Corrosion,* **10,** 367 (1954) Nov.

A problem requiring good ground-to-pipeline contact. Diagram.—BTR. 9380

5.2.2

Protecting Pipe Lines With Zinc Anodes. E. A. ANDERSON. New Jersey Zinc Co. *World Oil,* **138,** No. 6, 237-238 (1954) May.

A discussion of the application of zinc anodes in cathodic protection, including effects of zinc composition and backfill composition. What to expect from zinc anodes and their limitations is included. —INCO. 9356

5.2.3

Carbon Anodes. ROBERT POPE. *Corrosion,* **10,** No. 12, 443-444 (1954) Dec.

Advantages of cored rods for cathodic protection. Table.—BTR. 9326

5.2.3

Duriron Shows Good Performance as Anodes for Cathodic Protection with Impressed Currents. MARS G. FONTANA. *Ind. and Eng. Chem.,* **46,** No. 11, 75A-76A, 78A (1954) Nov.

In more than 2 years of laboratory and field testing, Duriron (14.5 percent silicon cast iron) anodes proved themselves excellently suited for use in cathodic protection systems involving impressed currents. Their main merit is low material consumption in acid, alkaline, and saline (sea-water) environments, even at high current densities. Graphite anodes do not give satisfactory life where high current densities are used. A Duriron anode installation in coal beds containing sulfur dioxide, sulfur trioxide, water, and acid performed satisfactorily where graphite anodes failed. In a fresh-water application, using impressed current, one Duriron installation showed definite superiority over aluminum anodes.

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used mostly in the protection of underground pipelines, water tanks, and maritime structures. With Duriron anodes, it could be used to a greater degree in chemical process industries, i.e., for equipment resting on the ground and for underground structures, particularly where chemical spillage threatens the life of less resistant anode materials.—PDA. 9429

5.2.1, 1.6

Cathodic Protection. Brochure, 1954, 68 pp. Society of Chemical Indutry, 56 Victoria Street, London, S. W. 1.

Papers presented at the Symposium, London, November, 1953, are printed together with the discussion.—BNF. 9374

5.2.1, 8.9.5

First Interim Report on Evaluation of Cathodic Protection on Norfolk Group Reserve Fleet Vessels. L. J. WALDRON AND R. L. BENEDICT. Naval Research Lab., Rept. No. 4317, March 2, 1954.—INCO. 9572

5.2.1, 8.9.5

Cathodic Protection in the Marine Field. W. G. WAITE. Paper before Norwegian Inds. Sev. Assoc., Corrosion Conf., Oslo, June 18, 1954. *Corrosion Technology,* **1,** No. 7, 229-232 (1954) Sept.

Cathodic protection, which can be used at every stage of a ship's life from the fitting-out period onwards, is discussed. Besides its main use for the protection of hulls, the method is applicable to propellers, stern gear, cargo compartments, and it can result in very considerable savings in repair costs. Cathodic protection of other marine structures, such as floating docks and mooring buoys, are discussed. In the past, scrap iron, steel or cast iron have been used for anodes, but of recent years, carbon and graphite have found increasing favor. 5 references.—INCO. 9393

5.3 Metallic Coatings

5.3.4

Diverse Properties Extend Engineering Use of Nickel Plating. J. B. MOHLER. *Iron Age,* **175,** No. 10, 100-103 (1955) Mar. 10.

Whatever the need for an engineering finish, nickel plating can usually produce the required properties. Nine basic electrolytic baths, plus many modifications, give wide selection of bath behavior and deposit properties. Two basic properties imparted by nickel plating—wear resistance and corrosion resistance—account for its many engineering and industrial applications. Deposits of high hardness or high ductility can be obtained. Good buffability, brightness and machinability also help to make nickel a highly versatile engineering finish. Compositions of 9 basic nickel baths and some physical properties of deposits are tabulated. Effect of pH and of bath temperature on hardness are shown in graphs. Electroless nickel plating has certain advantages over electrolytic process and is more readily applicable in many cases. Illustrations, 4 references.—INCO. 9617

5.3.4

An Experimental Investigation of the Metal Spraying Process. A. MATTING AND K. BECKER. *Electroplating and Metal Finishing,* **8,** 143-145 (1955) April.

Mechanisms of the metal spraying process and results obtained in investigations of the processes taking place at the wire end. Diagrams, photographs.—BTR. 9600

5.3.4

High Nickel Overlays on Ferrous Metals. G. R. PEASE, H. B. BOTT AND H. C. WAUGH. International Nickel Co. Paper before Am. Welding Soc., 35th Nat. Fall Mtg., Chicago, November 1-5, 1954. *Welding J.,* **34,** No. 1, 40-48 (1955) Jan.

Optimum welding conditions are defined and illustrative properties shown for Monel, "K" Monel, nickel and Inconel overlays on mild steel, deposited with flux-coated electrodes and by inert gas methods. Problems associated with obtaining satisfactory overlays on cast iron (containing 0.19-1.31 percent nickel) are also briefly discussed. Tables.—INCO. 9406

5.4 Non-Metallic Coatings and Paints

5.4.8, 8.9.5

Shipbottom Paints. W. J. FRANCIS. *J. Am. Soc. Naval Engrs.,* **66,** 857-866 (1954) Nov.; *Bureau of Ships J.,* **3,** 22-25 (1954) Oct.

Past, present, and future research and development in anti-corrosive and anti-fouling compositions. Photographs.—BTR. 9674

5.4.5

Zinc Dust as a Protective Pigment. Part II. J. BLOWES, M. J. F. MEASON AND A. PASS. *J. Oil Colour Chemists' Assoc.,* **37,** No. 411, 483-507 (1954) Sept.

A continuation of an earlier paper of the same title. The authors describe the behavior of air-drying zinc rich paints and the principles of formulation, experiments on the use of zinc-rich paints in comparison with other anti-corrosive compositions in sea water, and the use of zinc dust/zinc oxide oil paints as primers for wood and steel.—ZDA. 9788

5.4.5

Choosing Your Paint. E. JOHNSON. *Product Finishing,* **7,** 53-58, 108, 110 (1954) Feb.

Reviews factors to be considered including suggestions for various tests that can be applied for checking quality of paints.—BTR. 9730

5.4.5, 8.1.1

Protective Coatings—First Line of Defense Against Corrosion. P. O. BLACKMORE. *Interchem. Rev.,* **13,** No. 3, 75-84 (1954) Autumn.

Theory of corrosion of metals as an electrochemical phenomenon, including necessity of simultaneous presence of oxygen and moisture for corrosion, corrosion of iron at a rate proportional to that at which oxygen can be delivered to the cathode, and setting up of electrolytic cells from a number of causes, not necessarily involving the presence of dissimilar metals. Acute problem of developing suitable coatings for room air conditioners because of the abundance of oxygen and moisture provided by them is discussed. Two ways of inhibiting corrosion by eliminating eddy currents in the metal include passivating the cells, and barring cathode-stimulating oxygen by means of a primer, or film. Primers must possess adhesive and corrosion-resistant qualities and fill or seal pores or imperfections. Interlocking phenomena, adsorption, and chemical attack of the surface by a constituent of the film, as factors controlling adhesion, are considered. Importance of adequate cure, and other functions of coatings are discussed. Electromotive force series of elements is tabulated. Photomicrographs.—INCO. 9785

5.4.5

Organization and Administration of a Plant Painting Program. W. E. CHANDLER AND C. W. SISLER. *Corrosion,* **11,** No. 10, 433t-436t (1955) Oct.

Management is faced with the problem of selecting the combinaton of construction materials and paints which will result in the lowest possible maintenance and replacement costs. Developments in the paint field have been very rapid and it is necessary for plant maintenance organizations to re-evaluate painting programs because of this technical advancement.

A sound painting program must include the assignment of sufficient engineering and managerial personnel to the problem. Basic design should be studied in order that unnecessary painting be eliminated and necessary painting simplified. Engineering research studies should be conducted so as to make it possible to determine the materials most suited to the plant environment.

Once an adequate painting system is set up it must be maintained. Maintenance of the system should include periodic inspections and follow-ups; a continuing study of maintenance and replacement costs also should be made. Development of a well-engineered program properly administered normally will lead to more adequate protection with a considerable reduction in maintenance cost. 9725

5.4.5

Electrodeposition of Cellulose. C. L. MANTELL AND F. COZZARELLI. *J. Electrochem. Soc.,* **102,** No. 3, 110-112 (1955) Mar.

Cellulose has been plated at the anode from its 1 percent solution in alkaline sodium zincate containing 10 percent urea. Work was started with the object of recovery from factory wastes, but the deposit may prove useful as a protective coating for wire or gauze.—BNF. 9602

5.4.5, 1.6, 1.2.2

The Measurement and Control of Industrial Paint Finishing Costs. Book, 60 pp., 1955. Imperial Chemical Industries Ltd., London, S.W.1, England.

Three papers on ways of reducing painting costs.—MR. 9422

5.4.5

Action of Dry Zinc Chloride at Elevated Temperatures on Cotton-Seed Oil. (In Russian). E. P. BABIN AND V. G. PLYUSNIN. *J. Applied Chem.* (Zhurnal Priklad. Khim.), **27,** 463-465 (1954); *Chem. Abs.,* **48,** No. 13, 7917 (1954) July 10.

Zinc chloride acts as a catalyst for oxidation of the oil at elevated temperature as shown by a rise in the acetyl number on heating the oil to 240° in the presence of 10 percent zinc chloride. The I number declines sharply while the saponification number drops slightly in the course of a 21 hr. treatment.—ZDA. 9354

5.4.5

Zinc-Rich Paints. C. FINLAY AND C. T. MORLEY-SMITH. *Corrosion Technology,* **1,** No. 10, 383-385 (1954) Dec.

A general review of zinc-rich paints (92-95 percent metallic zinc in the dried

paint film). Some details of composition, formulation, manufacture, can storage, application and uses are given. The high pigment:binder ratio restricts the list of suitable media, the most popular types of binder being chlorinated rubber and polystyrene. For purposes of manufacture, mixing is all that is required. The can-storage properties are poor. The evolution of hydrogen arising out of the acidity of the medium or presence of moisture causes "gassing" or "blowing." There is also a tendency towards hard settlement due to the heavy nature and high concentration of the pigments. Application is usually by brush, though dipping or spraying are also possible. The zinc-rich paints afford sacrificial protection to steel. The adhesion is not particularly good, though this tends to improve on ageing, and resistance to abrasion is poor. These paints are largely used in priming of all types of steel work, while special applications include protection against corrosion fatigue and use as welding primers. Zinc-rich undercoats on ships' bottoms have met with considerable success. Among the other types of protective coatings based on zinc dust are mentioned zinc dust/zinc oxide paints and cementiferous paints comprising essentially zinc dust in a solution of sodium silicate.—RPI. 9679

5.4.5

Silicones in Protective Coatings. M. A. GLASER. *Ind. & Eng. Chem.*, **46**, No. 11, 2334-2342 (1954) Nov.

Preparation, properties and applications. Deals especially with heat- and weather-resistant enamels (e.g., pigmented with aluminum and/or zinc dust) for use on jet engines, furnaces, resistors, etc.—BNF. 9676

5.4.5

Corrosion-Retarding Effect of Red Lead Cyanamide. (In German.) HANS-J. SCHUSTER AND J. D'ANS. *Naturwissenschaften*, **41**, No. 16, 373 (1954) Aug.

Electrical measurements made to determine possible electrochemical reasons for above effect.—BTR. 9461

5.4.5

Lead Coating by Painting. (In German.) OSCAR NEUSS. *Werkstoffe u. Korrosion*, **5**, No. 4, 139-140 (1954) April.

A method of protection is described in which a coating of finely divided lead, with chlorinated rubber as a binder, is applied by brushing or spraying. The material, called "Plumbol," affords better protection against rusting of iron in a 3-year exposure test than ordinary red lead paint or red lead in chlorinated rubber. It is claimed that a single coat of Plumbol is equivalent in protective value to 3 or 4 coats of oil-bound paints. Protection is also given against attack by sulfuric acid, sulfurous acid, and alkalies, but not against nitroso gases or nitric acid. In general, a Plumbol coating is said to provide the same protection as would be given by an equal thickness of metallic lead.—MA. 9535

5.5 Oil and Grease Coatings

5.5.3, 5.8.2

Investigation of Some Liquid Lubricants for the Corrosion Protection of Steel Parts in the Process of Manufacture and in Storage. Part III. (In Russian.) V. V. SKORCHELLETTI AND V. E. PISKORSKII. *J. Applied Chem.* (Zhur. Priklad. Khim.), **27**, 314-318 (1954) Mar.

Greases made of petroleum jelly and technical vaseline were exposed to an atmosphere of 100 percent RH at 20-22°C, with and without various anticorrosive additives. Potassium chromate was the most efficient inhibitor of those tested. After 375 days, all uninhibited greases were 75 percent decomposed, whereas a petroleum grease thickened with 20 percent petrolatum to which 40 percent powdered potassium chromate had been added was unaffected. A concentration of 10 percent potassium chromate prevented oxidation of grease stored for 2-3 months. The chromate causes skin irritation, however, and is unsuitable for protecting metals which require handling.

Greases containing 2 percent and 3 percent barium soap of montan wax suffered 20 percent and 25 percent decomposition, respectively. Of the remaining additives tested, only sodium benzoate showed promise.

The mechanism of corrosion prevention by inhibited greases is considered to involve the formation, on the metal surface, of an anticorrosive aqueous film with water vapor, which would otherwise penetrate the grease layer.—PDA. 9525

5.8 Inhibitors and Passivators

5.8.3

The Effect of Organic Inhibitors on the Dissolving of Iron in Acids. (In German). J. ELZE. *Metalloberflache*, Sec. A, **8**, No. 12, 177-179 (1954) Dec.

Investigations with a redox electrode. The effect of inhibitors in the presence of an oxidizing agent. Tables, graphs. 8 references.—BTR. 9294

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5.8.3, 3.2.2, 6.3.6

A Natural Inhibitor of Pitting Corrosion of Copper in Tap-Waters. HECTOR S. CAMPBELL. *J. Applied Chem.*, **4,** No. 12, 633-647 (1954) Dec.

Polarographic studies and direct evidence from anodic-corrosion tests have indicated that many supply waters which might be expected to initiate pitting corrosion of copper cold-water piping contain a natural inhibitory agent which suppresses such corrosion. The inhibitor has not been identified, but it is associated with ultra-violet fluorescence of the waters containing it and is considered to be probably a negatively charged colloid of organic origin, since it depresses the polarographic maximum normally obtained with waters containing dissolved oxygen and has been deposited by electrophoresis on a positively charged platinum electrode. The inhibitory mechanism is not yet fully known, but is apparently concerned with modification of the cuprous oxide, or possibly cuprous chloride, produced at the anodic areas, resulting in the formation of an adherent protective film instead of a loose non-protective layer of coarse red crystals. A portable instrument specifically designed for the polarographic examination of waters for the presence of the corrosion-inhibitor is described and illustrated in an Appendix.—MA. 9277

5.8.3, 6.2.3, 4.3.2

Effect of Certain Inhibitors on the Rate of Solution of Carbon Steel in Nitric Acid. S. A. BALEZIN AND G. S. PARFENOV. *J. Applied Chem. U.S.S.R.* (Zhurnal Prikladnoi Khimii), **27,** No. 9, 930-938 (1954) Sept.

Above process investigated over a wide range of acid concentrations. Organic and inorganic inhibitors evaluated. Mechanism proposed. 4 tables, 8 figures, 27 references. Translation available: Assoc. Tech. Services, Box 271, East Orange, N. J.—ATS. 9352

5.8.3, 8.4.3

How Inhibitors Work in Subsurface Corrosion. J. D. CRAWFORD AND T. M. NEWELL. Cardinal Chem., Inc. *World Oil*, **139,** No. 7, 191-193, 196 (1954) Dec.

Review of corrosion control in producing oil wells. Acidic substances (hydrogen sulfide, carbon dioxide, and organic acids) dissolved in the brine of producing reservoirs cause corrosion of steel immersed in fluids containing the acidic brines and oils. The pH of the brine, temperature, crude composition, and water-oil ratio are factors influencing rate of corrosion. The mechanism of corrosion inhibition in oil wells, including the nature of the film produced by semi-polar organic inhibitors, and the extent of oil-wetting, is discussed, and the importance of maintaining a uniform treating schedule is emphasized. Age factor in corrosion failure was investigated and it was found that the frequency of failure constantly increases with time. Graph.—INCO. 9480

5.8.4

Studies on Amine-Type Corrosion Inhibitors. Part V. Behavior of Inhibitors in Hydrocarbon Oils. S. FUJII, K. ARAMAKI, M. ONOZUKA AND K. ISHITANI. *Corrosion Engineering*, **3,** No. 4, 32-34 (1954) Aug.

Amine-type corrosion inhibitors, which were made by reacting 1 mol. of higher fatty amines and 2-3 mols. of higher fatty acids, were tested for rust inhibiting qualities in hydrocarbon oils. The inhibitor consisting of C_{18}-amine and C_{18}-saturated acid performed best because of less wettability, temperate solubility in oil and covering ability of metal surface.—JSPS. 9672

5.8.4

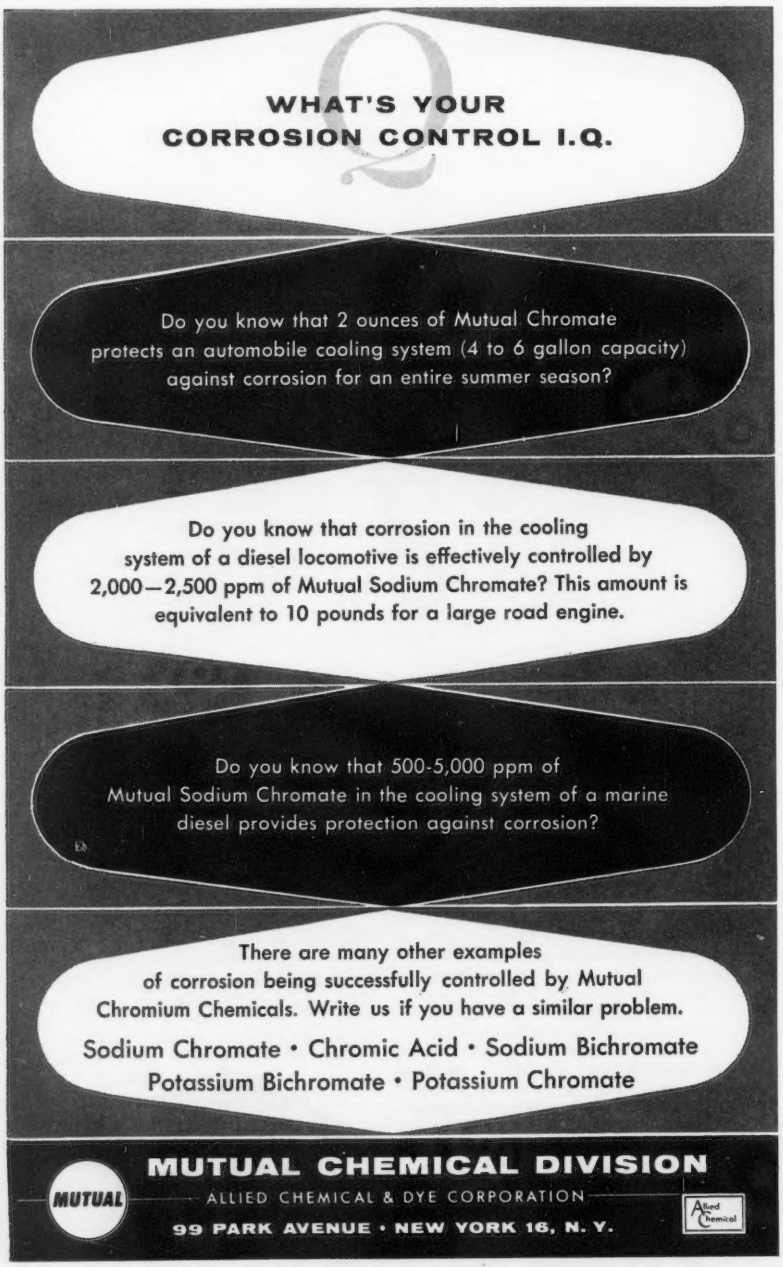
Studies on Amine Type Corrosion Inhibitors. Part III. Acids as Subsidiary Components of Amine-Inhibitors. S. FUJII, K. ARAMAKI AND I. UEHARA. *Corrosion Engineering* (Japan), **3,** No. 2, 26-30 (1954) April.

Among hexadecylamine-inhibitors (or octadecylamine-) effective ones could be found when they were made by reacting 1 mol. of amines with 2 or 3 mol. of acids. Various corrosion inhibitors consisting of n-hexadecylamines and various fatty acids were tested in sea water and in acidic solutions. C_8-C_{12} straight chain acids or unsaturated C_{18} ones exhibited best inhibitive qualities.—JSPS. 9671

5.8.4

Studies on Amine-Type Corrosion Inhibitors. Part IV. Behavior of Inhibitors in Aqueous Solutions. S. FUJII, K. ARAMAKI S. KOSUGI, AND Y. MURAYAMA. *Corrosion Engineering*, **3,** No. 3, 21-26 (1954) June.

Mainly the behavior of inhibitor molecules in neutral or acidic corrosive media were studied. The C_8-C_{12}-amine inhibitors, which can be easily emulsified by themselves, are used in these experiments. Neglecting effects caused by solvents, emulsifiers etc. encountered with the C_{16}-amine inhibitors, results of weight-loss tests are discussed with regard to their molecular structures.—JSPS. 9305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5.8.3

The Inhibition of Corrosion by the Pertechnetate Ion. G. H. CARTLEDGE. Oak Ridge National Lab. U. S. Atomic Energy Comm. Pubn., ORNL-1833, Jan. 18, 1955, 42 pp.

Theoretical consideration of alternative mechanisms to account for the action of inorganic corrosion inhibitors of the XO_4^{n-}-type led to the discovery that the pertechnetate ion, TcO_4^-, inhibits the corrosion of iron and carbon steels in aerated water at temperatures up to 250° C, which was the highest temperature investigated. By taking advantage of the radioactivity of technetium, it has been shown that inhibition may be achieved without precipitation of more than radiochemical traces of film, which is probably of secondary origin, and that exposures lasting almost two years have not been accompanied by a continuous increase in the amount of precipitated technetium. The perrhenate ion, ReO_4^-, though it is externally very similar to the pertechnetate ion, did not inhibit under any conditions investigated; both radioactive and stable rhenium isotopes were used in the tests. Attempts to measure adsorbed pertechnetate ions gave results barely beyond experimental uncertainty. Inhibition necessitated the maintenance of a certain minimum concentration of pertechnetate ions in the solution; this minimum was as low as 5×10^{-5} *f* at 100° C. in certain instances. The observations make it clear that inhibition arises from some intra-ionic property, rather than from forces due to an image charge of the ion as a whole or from some effect due to the tetrahedral oxygen atoms of the XO_4 ion.—NSA. 9448

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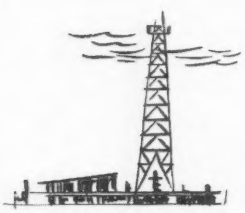

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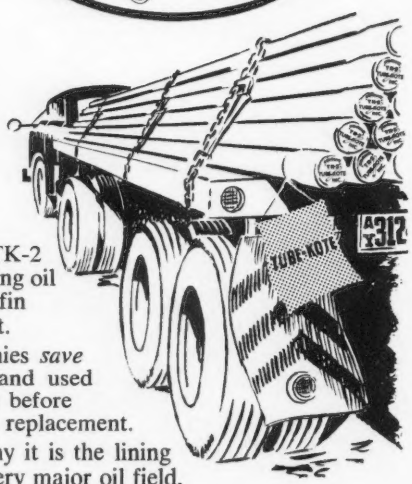

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5.8.3

The Electrochemistry of Inhibitor Action. R. B. MEARS. *Corrosion*, **11**, No. 8, 362t-364t (1955) Aug.

Principles involved in the electrochemistry of inhibitor action are discussed. Electrical terms are used to explain the inhibiting action of substances and to show what properties are desirable in an inhibitor. The mechanism by which sodium chromate and sodium hexametaphosphate function as inhibitors is discussed in detail. 9548

5.9 Surface Treatment

5.9.4, 3.8.4, 6.4.2

The Rectification Mechanism of Aluminum Oxide Layers in an Electrolyte Solution. KUNIO NEGASE. Mem. Inst. Sci. Ind. Research Osaka Univ. (Japan), **11**, 13-23 (1954); *Chem. Absts.*, **48**, No. 20, 11957-11958 (1954) Oct. 25.

A can fabricated from 99.99 percent aluminum, 0.35 mm thick, was sealed to a glow discharge tube having a vacuum connection. The can's outer surface was anodically coated with an oxide layer of a few μ. The can was evacuated, then made cathodic with respect to a platinum electrode dipped in the electrolyte. Hydrogen produced at the oxide-solution interface and diffusing into the oxide and its substrate was detected upon penetration of the can wall by a decrease in the voltage across the glow tube. The rate of the voltage decrease was proportional to the rate of diffusion in films produced in an ammonium borate solution. The thickness of the oxide layer was nearly proportional to the formation voltage. The rate of decrease of the discharge voltage depended inversely on formation voltage and directly upon the cathodic current. Similar experiments were performed with films formed in 0.1N sulfuric acid at a current density of 10 ma/sq cm for different times. Aluminum thickness was assumed to be constant. About one millionth of the generated hydrogen moved into the oxide layer under the influence of the electrical field. The static rectification characteristics of films as a function of formation voltage were plotted. Hysteresis was noted. Measurements of the decrease in cathodic voltage and increases in dielectric loss and capacitance with time were made. Without current flow, the electrode potential tended to recover with time while the capacity decreased. Somewhat more complex behavior was observed for films formed in ammonium borate solution and then made cathodic in pH 2.7 sulfuric acid solution. The cathodic voltage tended to a minimum with time and then increased. This was attributed to the creation of pores and intrusion of electrolyte. The simultaneous great increase in capacitance was accounted for by the decrease in film thickness. The behavior of films in pH 9.2 ammonia solutions was "normal." It was concluded that the entrance of hydrogen into the films caused a neutralization of the electronic space charge and a decrease in the potential drop across this layer.—ALL. 9452

5.9.4, 6.3.13, 3.8.4

Formation of Anodic Oxide Films on (Tantalum) Cathodes. D. A. VERMILYEA. *J. Electrochem. Soc.*, **101**, No. 8, 389-392 (1954).

The total voltage applied across an anodic film during its formation consists

Inco high temperature research note:

Carburization

...and its effects on metals at high temperatures

With sufficient background of information on the strength properties and corrosion characteristics, it should be entirely possible to predict the performance of an alloy under any conditions of high temperature service.

Method of Obtaining Data

Data relating to the mechanical properties may be obtained in the laboratory by any of the conventional testing methods . . . on the other hand, the problem of high temperature corrosion resistance is often so complex that it is frequently more convenient to place test specimens in an actual service environment than to try simulating industrial conditions on a laboratory scale.

This course is being pursued by Inco's high temperature engineers working in the field and in laboratories at Bayonne, N. J. and Huntington, W. Va. Creep and rupture tests at temperatures as high as 2100°F have supplied data on the strength properties of high nickel alloys. Corrosive attack by various hot atmospheres, fused salts and molten metals is being studied principally in the field to provide the type of information that will assist industry to select more suitable, longer lasting materials for various high temperature applications.

Effects of Carburization

Carburization—as may result from contact with carbonaceous atmospheres in petro-chemical or petroleum refining operations or during the heat treatment of steel parts—is one type of high temperature reaction which, under certain conditions, can change the properties of heat resistant alloys and adversely affect their performance.

Carbon diffuses into the metal and subsequently precipitates as a carbide particle rich in chromium. Compared to the alloy matrix, the carbide phase is hard and brittle. If distributed throughout grain boundaries, the particles provide a continuous path for brittle failure. (See micrograph below.) In certain types of service, carburization of a heat-resisting alloy may not be a serious matter. But in the usual case where the metal part or structure may be called upon to exhibit some measure of ductility or be subjected to impact or to drastic temperature changes, carburization often leads to premature failure.

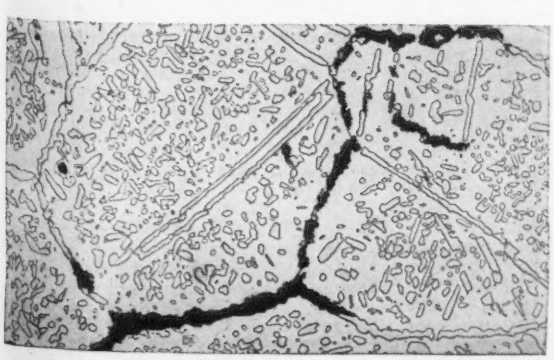
Nickel Plays Basic Role

In general terms, the susceptibility of iron-chromium-nickel alloys to carburization seems to depend upon the relative amounts of the individual components – but not as one might expect. Iron and chromium form stable carbides, while nickel does not. Yet Inco test data show that chromium has a greater effect than either iron or nickel. But it has also been demonstrated that for a given amount of chromium its beneficial effect is much greater at a higher nickel level than at a lower. Conversely, for given nickel content it would be expected that an alloy containing a higher chromium content would be more resistant to carburization.

Assistance Available

Inco high temperature corrosion test data also suggest that silicon improves carburization resistance, as does the presence of carbide stabilizing elements, such as titanium and columbium. Under extremely severe conditions of carburization, the effect of these elements is but temporary, and after sufficiently long exposure, their value is lost.

In a fast growing field such as this, it is impossible to have an immediate answer to every problem. But if high temperature performance is a problem to you, whether in present activities or in new projects, Inco High Temperature Engineers will do their best to help you. Let them send you the High Temperature Work Sheet . . . it is a big aid in getting the facts down clearly. Send for a copy now.



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of the voltage applied to the cell minus any polarization voltage at the cathode and resistive drop in the electrolyte, plus the potential of the electrochemical reaction. It is shown that, because of the latter potential it is possible to form an oxide film on tantalum even when the tantalum is considerably negative with respect to a hydrogen electrode. 2 references.—MA. 9517

5.9.4, 6.4.2

Effects of Working-Condition on Properties of Anodic Oxide Film on Aluminium. Part VI. Effects of Temperature and Voltage in Alternating Current Sulfuric Acid Process. TAKASHI KUNIMOTO, ELZO IKEDA, AND HIROSHI NISHIMURA. *Light Metals* (Japan), No. 10, 46-52 (1954) May.

In this part, the effects of bath-temperature and voltage on properties of anodic oxide film in alternating current sulfuric acid process is examined. Bath-temperature was varied from 10 to 30°C, voltage was varied from 10 to 20 V and the other factors were held constant, i.e. concentration of 20 percent and time 40 minutes. The inspection methods for the properties of oxide film were the methods specified in JIS P 10431, 1951, which were used in the preceding experiments. The results of the experiments are as follows: 1) The relation between thickness of film and bath-temperature and voltage is shown by following experimental formula: $T = 0.845e\ (0.0392h + 1.035V)$. When the bath-temperature reaches 30°C, this formula cannot be applied because of the severe corrosive attack of sulfuric acid. 2) The relation between thickness of film and electric power is $T = 1.8 + 0.35$ W. When the bath-temperature reaches 30°C, this formula cannot be used. 3) The relation between corrosion resistance and bath-temperature and voltage is shown by $S = (20.2\text{-}0.27H)e\ (0.0036h + 0.022)V$. When the bath-temperature reaches 30°C, this formula does not apply. 4) "Specific corrosion resistance" (corrosion resistance for unit thickness of film) of the film is reduced as the bath-temperature rises and the reducing rate is higher at lower voltage than at higher voltage. In comparison with DC anodizing method, this reducing tendency of the specific corrosion resistance is more remarkable in the AC anodizing method. 5) The relation between abrasion resistance and bath-temperature and voltage is shown by $A = 1.59e\ (0.0533h + 0.23V)$. At a bath-temperature of 25°C and 30°C, this formula cannot be applied. 6) The relation between abrasion resistance and thickness of film is shown by the experimental formula $A = 30T\text{-}100$. At the bath-temperature of 25°C and 30°C, this formula cannot be applied.—All. 9456

5.9.4, 6.4.2

Hard Anodising of Aluminum and Its Alloys. A. W. Brace. *Electroplating*, **7**, Nos. 9, 10, 329-334, 376-379 (1954) Sept., Oct.

Various processes which have been developed are discussed with details of practical operation. Variation in coating properties obtainable by altering the conditions. Mention is made of Aluminium Development Association's work on microhardness values and wear resistance. 18 references.—BNF. 9304

5.9.4, 6.4.2

Improving the Corrosion Resistance of Anodised Aluminium by a New Sealing Process. (In German). W. BRIESE. *Metallwaren-Ind. u. Galvanotechnik*, **45**, No. 8, 373-376 (1954).

Conventional practices in many firms is sealing in boiling water and subsequent applications of vaseline, etc. In the improved process described the work is dipped in running water, 2 min; dipped in 20 g/l sodium bicarbonate solution, 1 min; water rinse, 1 min, dipped for 2 min in vaseline at 160°C, drained and cooled. The corrosion resistance is increased 5 times over the conventional process. The work is sealed in boiling water and vaseline applied by hand.—EL. 9289

5.11 Design—Influence on Corrosion

5.11, 3.5.8

Machine Design for Cyclic Stress. J. S. CASWELL. *Engineer*, **198**, 318-321, 346-349, 378-381 (1954) Sept. 3, Sept. 10, Sept. 17.

New methods of design for resistance to fatigue failure are proposed, particular attention being paid to the effects of stress concentration.—BNF. 9284

6. MATERIALS OF CONSTRUCTION

6.2 Ferrous Metals and Alloys

6.2.2, 3.7.2

Researches on the Influence of Additions Hindering the Crystallization of Spheroidal Graphite in Cast Iron. J. PIASKOWSKI. *Prace Inst. Odlewn.*, **4**, Pt. 1, 142-150 (1954); *Bull. Brit. Cast Iron Res. Assoc.*, **12**, 559 (1955) Jan.

Reports results of work on harmful effects of residual elements (aluminum, titanium, lead, bismuth, antimony, tin) on formation of nodular graphite in magnesium-treated cast iron.—INCO. 9608

6.2.2, 3.7.3

Low-Heat Method of Welding Cast Iron. A. L. PHILIPS. *Welding Engr.*; **40**; Nos. 4, 5; 30-33; 47-48, 57 (1955) April, May.

Discusses briefly the forms of cast iron (white, grey and malleable) and characteristics of the metal leading to belief that cast iron welding should be avoided. Procedures which eliminate many of these problems include combating stresses by proper preheating, use of skip-welding and peening. Applications considered under oxyacetylene-torch welding are foundry flasks, glass molds and cylinder block, while electric-arc process is applied to repair of differential tractor housing and a 60-ton press. Special techniques in welding malleable cast iron are presented.—INCO. 9621

6.2.2, 5.8.3, 3.8.3

An Interpretation of the Significance of the Potentials of Passive Iron. M. J. PRYOR. *J. Electrochem. Soc.*, **102**, 163-169 (1955) Apr.

Explanation of effects of anodic corrosion inhibitors. Graphs. 23 references.—BTR. 9638

6.2.2, 3.2.3

The Surface Structure of Iron as Shown by Oxidation Experiments. E. J. CAULE. *Chem. Can.*, **6**, 42, 44 (1954) Sept.

Pure iron sheet specimens were exposed to dry oxygen at 300-400° C. and approximately 1/20 atm. pressure. Oxide film formation was followed by the Gulbransen vacuum-microbalance technique and by electron microscopy.

In the oxidation times allowed, the film thicknesses produced on pure iron ranged from 0 to above 1000 Å. From 300 to over 1000 Å these oxide films showed characteristic temper colors. Although the oxygen uptake followed a parabolic law over periods of the order of 60 hr., it was much higher than predicted by this law during the initial stage, owing probably to the oxidation of finely divided metal debris left on the metal surface from the usual hydrogen reduction of the air-formed oxide film.

Electropolishing produced the least active specimens of any surface preparation method used, but, as shown under the electron microscope, left the iron covered by a film of oxide at least 100 Å thick. Reduction of this diffusion barrier produced an active surface but destroyed the smoothness of the electropolish.—PDA. 9715

6.2.2, 3.7.3

Graphitization of Magnesium-Treated White Irons. C. M. HAMMOND, F. J. WALLS, W. B. PIERCE AND R. A. FLINN. Paper before Am. Foundrymen's Soc., 58th Ann. Mtg., Cleveland, May 8-14, 1954. *Trans. Am. Foundrymen's Soc.*, **62**, 385-388 (1954).

In magnesium-treated white iron spheroidal graphite may be obtained by heat treatment at very high graphitization temperatures (1900-2000° F.) in very short times (20-30 min.). Graphitization time at a given temperature is longer for heavier sections than for lighter sections even when the heavy section contains appreciable as-cast spheroidal graphite and light section contains no as-cast graphite. Above results indicate the possibility of rapid annealing of either white or partially graphitic magnesium-treated irons by treatment in molten salt or by induction heating. This should minimize scale formation and decarburization and improve dimensional tolerances. Graphs and photomicrographs.—INCO. 9699

6.2.2, 5.11, 1.6

Practical Guide to the Design of Grey Iron Castings for Mechanical Purposes. (In French.) Brochure, October, 1954, 56 pp. Editions Techniques des Industries de la Fonderie, 12 Avenue Raphaël, Paris 16e, France.

A valuable document in which detailed recommendations are made for the design of grey iron castings in respect of optimum strength, rigidity, fatigue resistance, soundness and ease of production.—BNF. 9705

6.2.2, 3.7.1

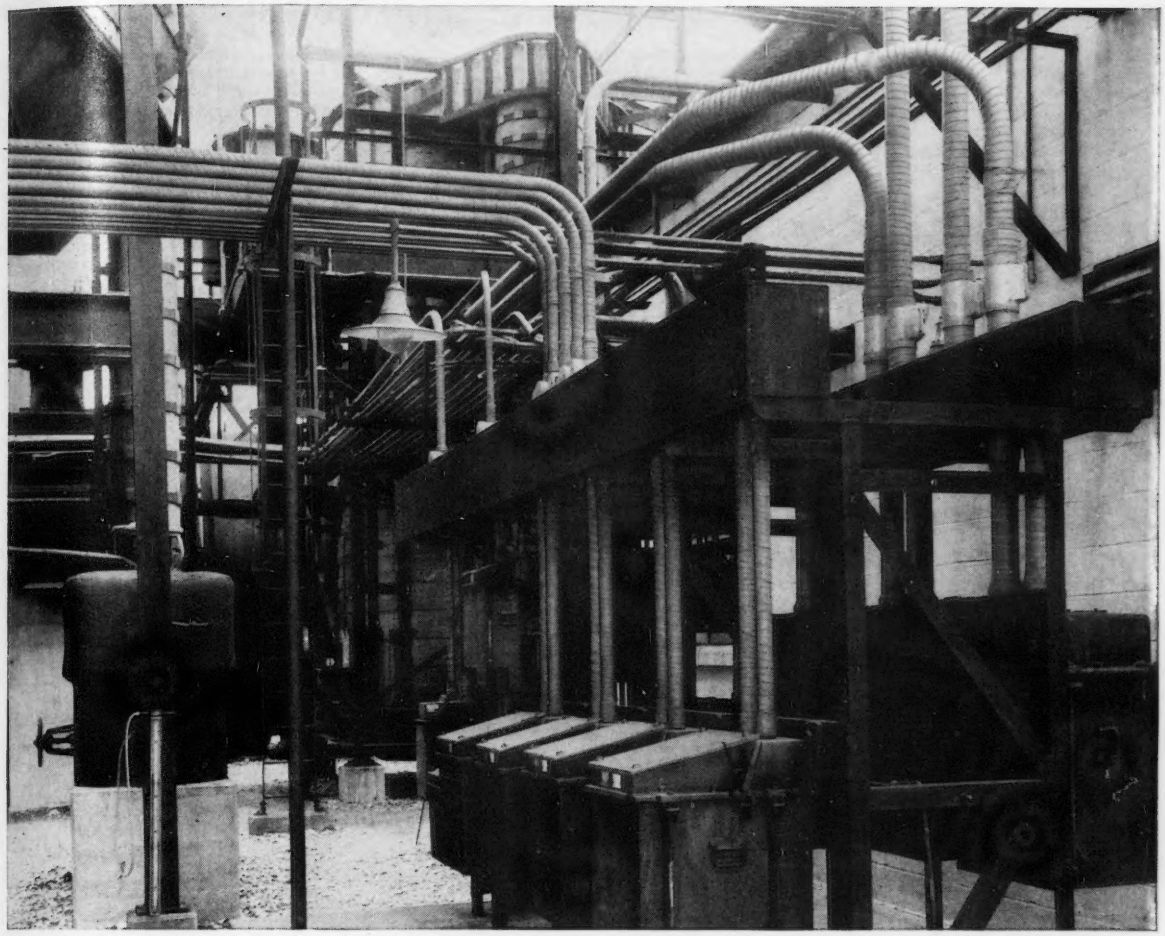
Contributions to the Knowledge on the Corrosion of Commercial Iron. (In German). ANTON KONIGER. *Giesserei*, **41**, No. 21, 565-569; disc., 569-570 (1954) Oct. 14.

Mechanism of corrosion in the presence of hydrogen ions; hydrogen-depolarizing effect of graphite; and corrosion-inhibiting effect of ionic oxygen. Also the effect of the cast skin, alloying components and previous treatment on its resistance to corrosion. Diagrams, photographs, graphs. 11 references.—BTR. 9166

6.2.2, 3.8.3

On the Passivity of Iron. KARL FRIEDRICH BONHOEFFER. *Z. Metallkunde*, **44**, No. 3, 77-81 (1953) March; Translation: *Corrosion*, **11**, No. 7, 304t-308t (1955) July.

Descriptions are given of the various phenomena associated with the passivation and reactivation of iron in concentrated nitric acid. Covered are apparent and true passivation potential, apparent and true passivation current density,



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passivity producing and passivity maintaining current density. Information is given also on equivalent current density in a redox system, the role of nitrous acid in passivation by concentrated nitric acid, the corrosion of passive iron, refractoriness toward activation, rhythms and activity waves. 9126

6.2.2, 6.2.3, 3.8.3

The Behaviour of Commercial Grades of Iron in Different Acids. A. KONIGER. *Giesserei,* **41,** No. 20, 522-527 (1954) September 30.

Potential measurements were made on cast irons (grey, white) and mild steel in nitric acid of varying concentration. Passivating influence of nitric acid on grey cast iron extends to concentrations exceeding 19.1 percent. Effects of the casting skin and its role as oxygen carrier are given. Gravimetric and gas-evolution methods of measuring corrosion rate were used.—INCO. 9165

6.2.2, 3.8.4, 3.2.3

The Structure of Oxidation Interface of Iron. (In French). RAYMOND SIFFERLEN AND ROBERT COLLONGUES. *Compt. rend.,* **238,** No. 22, 2167-2169 (1954) May 31.

Observation of thin zone of very fine crystals during first hour of oxidation. Micrographs. 4 references.—BTR. 9476

6.2.4, 3.2.3, 3.5.9, 3.7.2

Properties of Low Carbon Phosphorus and Copper Alloyed Structural Steels. II. High Temperature Oxidation. Accelerated Oxidation Phenomena of Steels in Presence of Phosphorus and Copper. (In Italian). COLLARI NELLO AND FONGI NELLA. *Metallurgia italiana,* **46,** No. 4, 111-112 (1954) April.

Efficiency of phosphorus. Formation of an eutectic phase melting around 800 C. Tables, graphs, micrographs. 15 references.—BTR. 8860

6.2.4

High-Strength Low-Alloy Steels. C. M. PARKER. Paper before Soc. Automotive Engrs., Materials Activity Mtg., Detroit, October 25, 1954. *Welding Research Council Bull.* Series No. 20, 1-5 (1955) Jan.

Novel applications of high-strength low-alloy steels in the automotive field and superior mechanical properties and corrosion resistance of these steels is presented. Most common alloying elements used in high-strength low-alloy steels are chromium, copper, manganese, molybdenum, nickel, phosphorus, silicon, titanium, vanadium and zirconium. Weldability of high-strength steels in the manufacture of dump trucks, delivery trucks, tank trucks, railway hopper cars and slag cars showed that longer life was obtained because of increased corrosion resistance.—INCO. 9620

6.2.5

Some Recent Developments in Stainless Steels. J. I. MORLEY. Brown Firth Research Labs. *Iron & Steel* (London), **28,** 143-146 (1955) April.

Review article covering steel for U. S. rail cars, martensitic transformation precipitation-hardening, cold-rolling and drawing, 17/7 PH, stainless W, martensitic 448 sheet steel, and effects of composition on transformation characteristics of 11-13 percent chromium steels.—INCO. 9664

6.2.5, 3.5.8, 3.7.3, 5.12

Stress Corrosion Cracking of Hardenable Stainless Steels. F. K. BLOOM. *Corrosion,* **11,** No. 8, 351t-361t (1955) Aug.

Hardenable stainless steels are susceptible to cracking under the combined influence of tensile stress and corrosion, depending on the severity of the stress, the nature of the media and, to a large extent, on their hardness. The most severe conditions are acid solutions containing sulfides, which promote entry of hydrogen into the steel and where chlorides are present to promote pitting. In such media cracking may occur in the standard grades under stress at hardnesses of Rockwell C24, in severe marine atmospheres at C40 and in industrial atmospheres at C45. Type 422, tempered at 1200° F. to Rockwell C30 and the precipitation-hardening alloys, 17-4 PH and 17-7 PH, overaged to the same hardness level, were the most resistant materials tested.

Types 410, 416 and 431 performed as well as or somewhat better than low alloy steels when heat treated to equivalent hardness levels. Tempering them at 1100° F. or higher temperatures provided good resistance to cracking in the severest media.

Internal stresses generated during quenching can promote stress corrosion cracking without imposing additional external stresses. Interrupted quenching (martempering) is helpful in minimizing stresses from this source and is recommended as a heat treating practice for parts used fully hardened in service likely to cause corrosion cracking. 9573

6.2.5

Corrosion. M. G. FONTANA. *Ind. and Eng. Chem.,* **46,** No. 5, 85A-86A, 88A (1954) May.

New alloy recently announced by U. S. Naval Ordnance Lab. contains 15-16 percent aluminum, 3 percent molybdenum, balance iron and is designated Thermenol. This material shows considerable promise as a high temperature, high strength, oxidation resistant alloy and also shows good resistance to aqueous environments. Corrosion data on Thermenol are not available at present but its corrosion resistance should be as good or better than the Alfenol or straight aluminum-iron alloy. Tests on aluminum-iron alloys in fresh and sea water are tabulated and results compared with those of 5 percent nickel steel, mild steel and stainless steel. Graph.—INCO. 9433

6.2.5

Corrosion-Resistant Cast Alloys. E. A. SCHOEFER. *Machine Design,* **26,** 178-186 (1954) Dec.

A design guide for selecting cast stainless alloys for fabricating characteristics, mechanical properties, and cost. Graphs, photographs, tables, 5 references. —BTR. 9302

6.2.5, 3.5.7

Special Steels for High Pressure Installations in Chemical Industry. (In German). I. Class. *Werkstoffe und Korrosion,* **5,** No. 8/9, 281-285 (1954) Aug.-Sept.

Review of the development of special steels for high-pressure duty in chemical industry. Steels discussed include low nickel-chromium, vanadium-chromium, vanadium-molybdenum-chromium, vanadium-tungsten-molybdenum-chromium, chromium-molybdenum, chromium-tungsten-vanadium steels. Physical and mechanical properties, effects of physical and chemical action of hydrogen, on properties of steel, surface protection and behavior of steels under high alternating internal pressures, such as in pump applications, are described. —INCO. 9405

6.2.5, 3.8.3, 3.6.8

The Phenomenon of the Disturbance of the Passive State of Stainless Steels in Strongly Oxidizing Solutions. (In Russian.) N. D. TOMASHOV AND G. P. CHERNOVA. *Doklady Akad. Nauk SSSR,* **98,** No. 3, 435-438 (1954) Sept. 21.

Anodic and cathodic polarization of various steels. Graphs. 10 references.—BTR. 9520

6.2.5, 4.7

Evaluation of Ferritic Substitutes for the Austenitic Stainless Steels. 1. Resistance to Attack by Sodium. E. G. BRUSH AND R. F. KOENIG. U. S. Atomic Energy Comm. Pubn., KAPL-1103, April 22, 1954, 47 pp.

The ferritic chromium-iron alloys have several advantages which make them attractive substitutes for the austenitic stainless steels in sodium-cooled nuclear power plants where primary coolant temperatures will not exceed 1000°F. The principal advantages are lower cost, greater availability, lower thermal expansion, and higher thermal conductivity. The resistance of the chromium-iron alloys to attack was evaluated in sodium at temperatures of 500 and 700°C in a series of static and dynamic laboratory tests. Results indicated that steels containing 12 percent chromium are as resistant to attack by solution and mass transfer in filtered sodium at 500°C as the austenitic stainless steels, do not decarburize in filtered sodium at 500°C, and are more susceptible to corrosion in sodium containing more than 0.01 percent by weight of oxygen at 500°C than the austenitic stainless steels. The results further indicated that the 12 percent chromium-iron alloy decarburized at a rate of 0.04 mil/hr in continuous immersion (2160 hr.) in sodium containing 0.01 percent oxygen at 700°C, but did not decarburize in intermittent immersion in sodium at 649°C containing between 0.003 and 0.015 percent oxygen. Additional tests are in progress to determine the effects of stress and local oxide contamination on the corrosion of the chromium-iron alloys at 500°C in filtered sodium, to evaluate decarburization up to 800°C in sodium containing 0.003 percent oxygen, and finally to evaluate diffusion welding behavior. The operation of a large-scale 12 percent chromium-iron alloy heat transfer sodium system is desirable to substantiate laboratory data, which show the 12 percent chromium-iron alloy to have promise as a construction material for sodium service at temperatures up to 1000°F. (auth).—NSA. 9298

6.3 Non-ferrous Metals and Alloys—Heavy

6.3.3, 1.6

Malleable Chromium and Its Alloys. E. T. HAYES. U. S. Wright Air Development Center, Tech. Rept. No. 52-54, 1952 (unclassified 1954), 56 pp. (on microcards).

Improvements in the production of high-purity chromium metal by magnesium reduction of the anhydrous chloride and by the hydrogen treatment of electrolytic chromium are described; in the latter process increasing the treatment time from 8 to 16 hr. at 1200° C. produced a material suitable for arc-melting. Arc-melted, hydrogen-treated chromium can be forged

to 60 percent reduction without cracking. Rolling of arc-melted chromium was difficult owing to the large grain-size, but this was overcome by careful annealing. Hydrogen-treated chromium had less oxide inclusions than the original material, and this in turn had fewer inclusions than either Goldschmidt or chloride-produced material. Hardness could not be correlated with microscopic oxide. Arc-melted chromium is forgeable at liquid-nitrogen temperature; it is suggested that a low-temperature transformation may occur and that the low-temperature form is ductile. Drip melting of chromium powder-compact bars in pure hydrogen resulted in no improvement in quality. Deoxidation of chromium metal powder on melting in beryllium oxide with additions of various metals gave no improvement in quality; beryllium and thorium additions gave very soft products. Addition of titanium and zirconium up to 5 percent did not reduce the oxide content and increased the hardness and decreased the ductility of the material. Some grain-boundary clean-up was affected by treatment in molten calcium and calcium hydride. Arc-melted chromium can be swaged, forged, and rolled; chromium sheet spot-welds readily to either chromium or iron. The recrystallization temperature of rolled sheet was 750° C. Hot-hardness curves showed very little alteration in the range 300°-800° C. Hot-bending test results on both chloride- and hydrogen-treated chromium are presented. The present status of chromium in relation to the metallurgy of molybdenum and tungsten is discussed. Oxidation-resistance was found to be excellent up to 1000° C. in air and penetration was low. The reason for the lack of room-temperature ductility has not been discovered, but there appears to be a possibility of achieving some cold ductility in arc-melted chromium. 23 references.—MA. 9754

6.3.6

Pinhole Porosity in Brass and Gunmetal Castings. N. B. Rutherford. *Foundry Trade J.*, **97**, 13-20 (1954) July 1; Abridged: *Metal Industry*, **85**, No. 1, 5-8 (1954) July 2.

Work done by the British Non-Ferrous Metals Research Association. Pinhole porosity on the surface of brass and gunmetal fittings was traced to the incorporation of wheat flour into the moulding sand for the improvement of surface finish. The most satisfactory alternative sand addition was found to be pelleted pitch. (This is based on Tech. Memo. 122, made available to B.N.F.M.R.A. members in April, 1954).—BNF. 9317

6.3.6

End-Quench Experiments with Aluminum Bronze. A. R. Bailey and H. C. Skevington. *Metal In.*, **85**, No. 14, 285-288 (1954) Oct. 1.

The end-quenching technique is applied to demonstrate praphically the anomalous behavior between hypo-eutectoid and eutectoid aluminum bronzes, and to provide an indication of the depth effect. Alloys containing nickel are included to show that the technique provides a method of gauging the effect of extra elements on the response to hardening.—BNF. 9350

6.3.6, 1.6

ASTM Standards on Copper and Copper Alloys. Book, September, 1954, 584 pp. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

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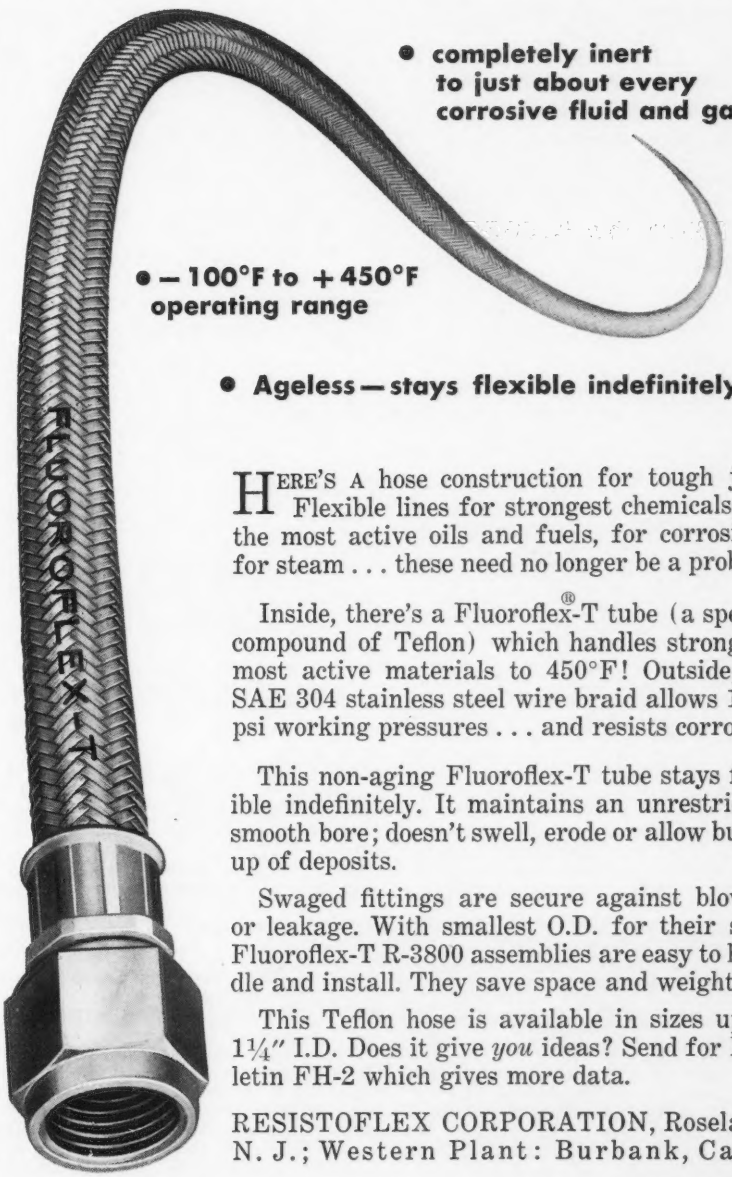

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71a

ing copper, copper-alloy and copper-covered-steel electrical conductors; plate, sheet, strip and rolled bar; rod, bar, shapes and die forgings; wire; pipe and tube; ingot; castings; filler metal; various methods of test. 50 of the specifications in this edition have been revised and eight are new. A detailed index is provided.—BNF. 9346

6.3.6, 3.5.9, 3.8.4

Effect of Oxygen on the Surface Behaviour of Copper (at High Temperatures). FRIEDRICH ERDMANN-JESNITZER AND FRITZ GUNTHER. *Z. Metallkunde,* **45,** No. 6, 407-412 (1954) June.

A comparison is made of the lattice structures, the vapor pressures, and the dissociation pressures of copper and its oxides cuprous oxide and cupric oxide, the relevant data being extracted from the literature. The results show that the oxidation of copper at high temperatures can be related not only to the kinetics of formation and decomposition of the oxides, but also to vaporization and surface diffusion of copper. 22 references.—MA. 9643

6.3.6, 3.7.2

The Creep and Fatigue Properties of Some Wrought Complex Aluminium Bronzes. J. MCKEOWN, D. N. MENDS, E. S. BALE AND A. D. MICHAEL. *J. Inst. Metals,* **83,** Pt. 3, 69-79 (1954) Nov.

The tensile, creep, fatigue, and corrosion-fatigue properties of some aluminum bronzes containing 0-11.5 percent aluminum and 5 percent each of iron and nickel, were examined. Creep tests at 300° and 400°C indicate that alloys with 3-7 percent aluminum have the best creep properties, but since they are relatively difficult to forge, the best combination of creep properties with ease of forging is obtained by using alloys with 9-9¾ percent aluminum. Fatigue tests at room temperature in air reveal no major difference between alloys with aluminum contents of 9-10½ percent. Some decrease in endurance limits was observed in tests at 400°C, and at this temperature the continued fall of the endurance limit with decreasing stress was more marked than at room temperature. Aluminum bronzes were more resistant to corrosion-fatigue in salt solution than a stainless steel and stainless iron tested for comparison purposes. Graphs, tables, photomicrographs. 5 references.—INCO. 9529

6.3.6, 6.3.19, 3.2.3, 3.8.4

The Oxidation of Copper and Zinc. E. R. S. WINTER. *J. Chem. Soc.,* **1954,** 3342-3344, Oct.

Studies of oxidation mechanism in terms of defect structures.—BTR. 9488

6.3.12, 1.6

Investigations of Rhenium. C. T. SIMS, C. M. CRAIGHEAD, R. I. JAFFEE, D. N. GIDEON, E. N. WYLER, F. C. TODD, D. M. ROSENBAUM, E. M. SHERWOOD, AND I. E. CAMPBELL. Battelle Memorial Inst. U. S. Wright Air Develop. Comm. Tech. Rept. 54-371, June, 1954, 147 pp.

Methods for the preparation of fine rhenium powder from potassium perrhenate and ammonium perrhenate are discussed in detail. Consolidation of this powder by pressing and sintering into a sound massive bar is included. The metal was fabricated into rod, wire, sheet, and foil by cold-working and annealing procedures developed after hot working proved impractical. The metal was also made available in arc-melted and crystal-bar forms, and electroplating procedures were developed. Various physical, mechanical, and electronic properties were determined on the available stock. The melting point was 3180°C; the density 21.0 g/cm³; the electrical resistivity 19 to 21 microhm-centimeters; the vapor pressure slightly more than that of tantalum; the spectral emissivity 0.36 to 0.42; and the thermal expansion 6.8×10^{-6} per cm for 0 to 1000°C. Rhenium has a Young's modulus of about 67×10^6 psi, is ductile at room temperature, and, when annealed, has a tensile strength of about 170,000 psi at room temperature. It work hardens greatly and has high elevated-temperature strength, but low ductility. Recrystallization occurs around 1300 to 1500°C. A guard-ring diode was constructed and the thermionic emission characteristics of rhenium determined; the work function is 4.80 ev and the Richardson constant 52 amp/cm²/K.² Additions of thoria to rhenium did not produce enhanced emission, as with tungsten. Emission constants determined on cathodes impregnated with barium aluminate are believed to be incorrect because of poisoning. Rhenium was found to have a far greater resistance to the deleterious water cycle than tungsten. Electrical-contact tests showed that, under the test conditions, rhenium was superior to tungsten and platinum—ruthenium. The oxidation resistance is good at room temperature, but a volatile oxide forms above 600°C. Porosity appeared in rhenium filaments above 2300°C, but was eliminated when rigid impurity control was invoked. (auth).—NSA. 9300

6.3.14

Germanium-Stabilised Grey Tin. A. W. EWALD. *J. Applied Physics,* **25,** No. 11, 1436-1437 (1954) Nov.

Grey tin containing 0.75 percent germanium does not reconvert to white phase for many months at room temperature and does so at an appreciable rate only at temperatures above 60°C.—BNF. 9634

6.3.14, 4.4.7

The Corrosion of Tin by Acetic Acid Dissolved in Organic Liquids. (In French.) RENE DUBRISAY AND FRANCOIS ARLET. *Bull. soc. chim. France,* No. 3, 314-315 (1954) Mar.

Experimental results. Characteristics of products of corrosion which vary greatly with nature of the liquid solvent. Micrograph. 13 references.—BTR. 9494

6.3.15

Titanium Fills Need for Super Material in Aircraft of the Future. N. E. PROMISEL. *J. Metals* (Trans. AIME), **7,** No. 3, 443-448 (1955) Mar.

After a brief general discussion of uses of titanium in which it might have advantage over conventional materials, discusses high temperature strength characteristics and includes a graph showing relative weight in tensile applications at various temperatures for titanium alloys, aluminum alloys and stainless steel; creep strength; supply and requirements. Finally there is a concise listing of current advantages and deficiencies of titanium properties.—BNF. 9639

6.3.17, 3.8.4, 3.4.6

Reaction of Hydrogen with Uranium. W. M. ALBRECHT AND M. W. MALLETT. Battelle Memorial Inst. U. S. Atomic Energy Comm. Pubn., BMI-982, Feb. 17, 1955, 21 pp.

The reaction of hydrogen with uranium was studied in the temperature range 96 to 400° C. at pressure levels of $p-p_o$ equal to 430, 150 and 70 mm. of mercury (where p is system pressure and p_o is the plateau dissociation pressure of the uranium hydride product). Reaction rates followed the linear law. At the pressure investigated, the linear rate constant increased with increasing temperature in the range 96 to about 250° C. and decreased with increasing temperature from about 250 to 400° C. The variation of temperature and pressure with the linear rate constant in the range 96 to about 250° C. is given by the equation: $k = 4.11 \times 10^{-3} (p-p_o)^{4/5} \exp(-1820/RT)$, where k is in units of ml per cm² per sec and $p-p_o$ is in units of mm. of mercury. Two different initial reactions were obtained. One in the range 96 to about 250° at $p-p_o$ of 70 and 150 mm. of mercury and 96 to 400° C. at $p-p_o$ of 430 mm. of mercury showed a gradual increase in the rate of hydrogen consumption until the rate became linear. The other initial reaction followed the parabolic rate law in the range of about 250 to 400° C. at $p-p_o$ of 70 and 150 mm. of mercury. Adsorption plays an important role in the over-all reaction mechanism of uranium with hydrogen. In the range 96 to about 250° C., the rate of adsorption is faster than the rate of reaction to form hydride, but it is of the same order of magnitude. Therefore, formation of hydride is the rate-determining step. However, in the range of about 250 to 400° C. the rate of adsorption is probably the rate-controlling step, with the exception of the initial parabolic reaction which would be diffusion controlled. (auth.)—NSA. 9297

6.3.20

Melting and Fabrication of Zirconium. J. W. HOLLADAY AND J. G. KURA. Nuclear Engineering, Chemical Engineering Progress Symposium Series, **50,** No. 11, 23-30 (1954) : Am. Inst. Chem. Engrs., New York.

Extraction, melting, fabrication, joining methods and uses of zirconium; effect of contamination by oxygen, nitrogen, hydrogen or carbon on mechanical properties; corrosion resistance; uses other than in nuclear reactors. 36 references, some to unpublished work, but no reference is made to G. L. Miller's book.—BNF. 9723

6.3.15

Mechanical Properties of Cast Titanium-Aluminium Alloy. R. E. EDELMAN AND A. TABAK. *Trans. Am. Foundrymen's Soc.,* **62,** 304-307 (1954).

Describes the results of tensile, Charpy impact and hardness tests on titanium-aluminum binary alloys (0.7 percent aluminum) arc-melted and cast into graphite moulds.—BNF. 9644

6.3.15

Electron Diffraction Studies on the Nature of the Corrosion and Heat Resistance of Titanium. T. NAKAYAMA. Repts. Casting Res. Lab., Waseda Univ., No. 5, 57-59 (1954).

Protective film of titanium exposed to sea water was studied by electron diffraction method. Film having a sufficient thickness for electron diffraction study was prepared in an autoclave. Results showed that a thin rutile film, formed on the surface layer of titanium exposed to sea water or oxidizing atmosphere, protects the substrate. Tables and four references.—INCO. 9530

6.3.15, 1.6

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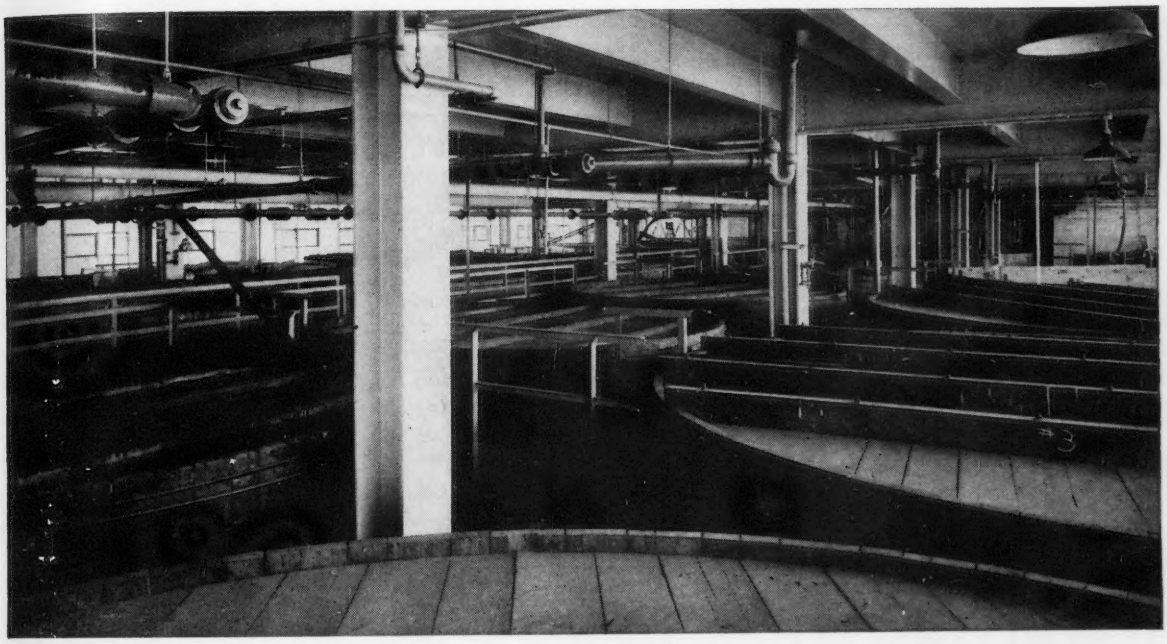

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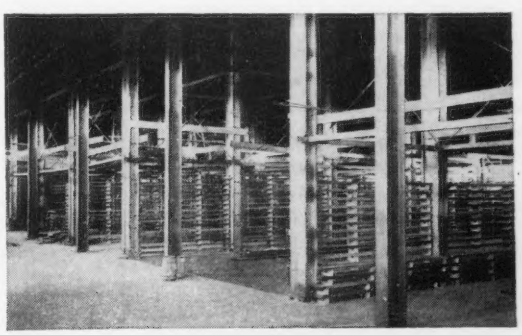

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73a

Structural, Electrical, Magnetic and Other Physical Properties. G. SKINNER, H. L. JOHNSTON AND C. BECKETT. Book, 1954, 174 pp. Herrick L. Johnston Enterprises, 540 W. Poplar Street, Columbus, Ohio, U. S. A.

This survey, claimed to cover most of the pertinent literature up to and including 1951, includes data on the preparation and properties of titanium, its hydrides, oxides, halides, nitride and carbide, and the alkaline earth titanates. Calculations of thermodynamic properties of many of these substances were made and the values are tabulated in appendices. 553 references. —BNF. 9327

6.3.15, 6.3.20

Corrosion Studies on Titanium and Zirconium Metals: Semi-Annual Report. L. B. GOLDEN. U. S. Atomic Energy Comm. Pubn., AECU-1299, 1951 (unclassified 1954), 30 pp. (on micro-cards).

Details are given of the results of tests on the corrosion-resistance of zirconium and zirconium alloys in solutions of hydrochloric acid, sulfuric acid, phosphoric acid, and organic acids. A comparison was made of the relative corrosion-resistance of arc-melted zirconium and material induction-melted in graphite crucibles. Titanium was tested in sulfuric acid, nitric acid, sodium tribasic orthophosphate, and stannic chloride solution. The following compounds were used in carrying out tests on titanium, zirconium, and stainless steel: cupric chloride,

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mercuric chloride, nickel chloride, manganese chloride, stannic chloride, aluminum chloride, calcium chloride, sodium chloride, and ammonium chloride; various chlorinated hydrocarbon-water mixtures were also used. A series of zirconium alloys were subjected to 30-day salt-spray tests in a 3 percent sodium chloride solution and in synthetic sea-water. —MA. 9627

6.3.15, 6.3.20, 6.3.9, 6.3.13

Less Common Metals (as Chemical Engineering Materials of Construction). W. R. Bekebrede and L. F. Yntema. *Ind. and Eng. Chem.*, **46**, No. 10, 2130-2135 (1954) Oct.

Part of the eighth annual Chemical Engineering Materials of Construction Review. Corrosion resistance, fabrication, applications, etc. of titanium, zirconium, molybdenum and tantalum. 35 references.—BNF. 9358

6.3.16

Heavy Metals (Tungsten-Nickel-Copper Alloys). Don Wackerle. *Machine Design*, **26**, No. 5, 143-147 (1954).

The importance of specially heavy metals is stressed, it being shown that the pure metals are not satisfactory either owing to bad machinability or because of cost. Details are given of the properties of Mallory 1000, an alloy of tungsten 90, nickel 6, copper 4 percent, having a α of ~16.9 g/cc. Methods of production are outlined, and an account is given of some applications of heavy metals as rotating inertia members, counterweights, and for radioactive shielding. This heavy alloy can be obtained with excellent surface finishes after machining. Its corrosion-resistance is better than that of 18:8 stainless steel in 20 percent hydrochloric acid.—MA. 9558

6.3.20, 3.7.1, 4.6.1

Corrosion of Zirconium in High-Temperature Water. D. E. Thomas. Nuclear Engineering, Part II, Chem. Eng. Progr. Symposium Ser. No. 12, 16-22 (1954): Am. Inst. Chem. Engrs., New York.

The corrosion of iodide-process zirconium in high-temperature water is reviewed. The kinetics of the corrosion reaction are given as a function of temperature and are characterized by a more or less protracted initial period of slow corrosion followed by a period of more rapid corrosion. The effects of impurities, surface preparation, mechanical deformation, metallurgical structure, and water purity are discussed. (auth).—NSA. 9392

6.3.20, 3.8.4, 3.2.2

Diffusion of Hydrogen and Deuterium in High-Purity Zirconium. Earl A. Gulbransen and Kenneth F. Andrew. *J. Electrochem. Soc.*, **101**, No. 11, 560-566 (1954).

The kinetics of the reactions of zirconium with hydrogen and deuterium were studied, by a vacuum-microbalance technique, over the temperature range 60°-250°C at pressures of 1.1-5.0 cm Hg, for the composition range zirconium to $ZrH_{1.7}$. The reaction was shown to be diffusion-controlled with diffusion from a surface of constant concentration into a heterogeneous system. The data for the diffusion of hydrogen in zirconium is given by the equation: $D = 1.09 \times 10^{-2}$ log exp(–11,400/RT)cm²/sec. At hydrogen concentrations above $ZrH_{1.6}$, there were some deviations from this equation. The data for the diffusion of deuterium in zirconium is given by: $D = 0.73 \times 10^{-2}$ log exp(–11,400/RT)cm²/sec. The relation between the diffusion coefficient of hydrogen and deuterium was found to be 1.5; the theoretical value is $\sqrt{2}$. 17 references.—MA. 9503

6.3.21, 3.8.4

Irreversible Potentials and Corrosion Behavior of Manganese. (In Russian.) A. Ia. Shatalov and N. I. Isaev. *J. Phys. Chem.* USSR (Zhurnal Fizicheskoi Khimii.), **28**, No. 9, 1562-1571 (1954) Sept.

Mechanism of corrosion at different pH's, using the method of polarization diagrams. Diagrams, tables. 17 references. —BTR. 9466

6.4 Non-ferrous Metals and Alloys—Light

6.4.2, 1.1

The Aluminum Association Alloy Designation System for Wrought Aluminium. Pamphlet, July, 1954, 4 pp. Aluminum Association, 420 Lexington Avenue, New York 17, N. Y.

As from October 1, the U. S. aluminum producers will use a new system for designating wrought aluminum alloys. The system is based on four digit numbers, the first digit representing the general group (1 for 99.0 percent min. aluminum; 2-7 for major alloying elements copper, manganese, silicon, magnesium, magnesium plus silicon, and zinc respectively; 8 for others and 9 unused at present). In the 2xxx-8xxx series, the last two digits indicate individual alloys (where possible, same numbers as used at present) and the second digit any modification. Thus alloy 3S will now be called 3003, and 24S will be 2024. In the 1xxx series, the last two digits indicate minimum aluminum composition (1030 will be 99.30 percent min. aluminum), and the second digit special control of some impurity.—BNF. 9313

6.4.2, 3.7.3

Research on the Electro-Chemical Properties of Aluminum-Copper Alloys. Part I. Hiromitsu Harimoto. *Light Metals* (Japan), No. 11, 51-54 (1954) June.

The relationship between ageing and hydrogen evolution of 17S alloy (Duralumin) was studied. Samples were water quenched from 505°C, and then tempered at 130°C and 165°C. Ageing duration times were 1, 2, 3, 6, 12, and 24 hr., and 2, 3, 4, 5, 6, and 7 days. After these heat-treatments, the specimens were dipped in 10 percent sodium hydroxide solution for 30 min, and then their hydrogen evolution was measured in 10 percent, 20 percent and 30 percent hydrochloric acid solutions. Conclusions were: 1) The longer the dipping time, the more the hydrogen evolution. 2) There seems to be some relationship between ageing and hydrogen evolution.—ALL. 9673

6.4.2, 1.6

Chemical Behavior of Aluminum. (In German.) Book, 1955, 333 pp. Aluminum Verlag GmbH, Jagerhofstrasse 26/29, Dusseldorf, Germany.

Narrative and tabulated data on the influence of various physical states and the degree to which aluminum is corroded by numerous media. There are 50 pages of tabulated data showing the resistance of the metal versus specific corrosives, and an extensive alphabetical subject index. 9576

6.4.2, 3.7.2, 3.7.3, 3.2.2

Intergranular Corrosion of High-Purity Aluminum in Hydrochloric Acid. Part I. Effects of Heat Treatment, Iron Content, and Acid Composition. M. Metzger and J. Intrater. U. S. National Advisory Committee for Aeronautics, Tech. Note No. 3281, Feb., 1955, 38 pp.

Functions of iron content, heat treatment, and acid composition in intergranular corrosion of aluminum in hydrochloric acid. Behavior of specimens quenched to retain a single-phase structure indicated rate of attack on high-angle boundaries to be influenced by segregation of iron and other impurity atoms. This segregation reduces rate of attack. Rapid attack occurs where there is a continual evolution of hydrogen gas from the crevice and is obtained in low acid strengths by increase in copper or iron content of the acid. Metallic impurities are responsible for preferential corrosion of the grain bodies in specimens with relatively inactive boundaries. Tables, photomicrographs, 18 references.—INCO. 9595

6.4.2, 3.7.4, 3.2.2

Intergranular Corrosion of High-Purity Aluminum in Hydrochloric Acid. Part II. Grain-Boundary Segregation of Impurity Atoms. M. Metzger and J. Intrater. U. S. National Advisory Committee for Aeronautics, Tech. Note No. 3282, April, 1955, 33 pp.

Variation in the rate of intergranular corrosion of single-phase high-purity aluminum in 20 percent hydrochloric acid as a function of iron content and final-annealing temperature is attributed to the segregation to atomic sites in the grain-boundary region of iron and possibly other impurity atoms. Experimental results are analyzed by reference to a distribution function, obtained by statistical mechanical methods, which gives the equilibrium fraction of certain sites in the boundary which are occupied by solute atoms in terms of the interaction energy for segregation of the solute atoms at these sites. Tables, graphs and 19 references.—INCO. 9596

6.4.2, 3.8.3, 2.3.9

The Porosity of the Aluminum Surface Investigated by the Repetitive Oscillographic Method. W. Machu, E. M. Khairy and M. K. Hussein. *Corrosion*, **11**, No. 9, 375t-378t (1955) Sept.

Experiments are reported using a repetitive oscillographic method to investigate the anodic behavior of spectroscopically pure aluminum exposed to a variety of electrolytes including buffer solutions of pH 6, 7 and 8, sulfuric acid and sodium sulfate, nitric acid and sodium nitrate, hydrochloric acid and sodium chloride, acetic acid, oxalic acid and disodium hydrogen phosphate.

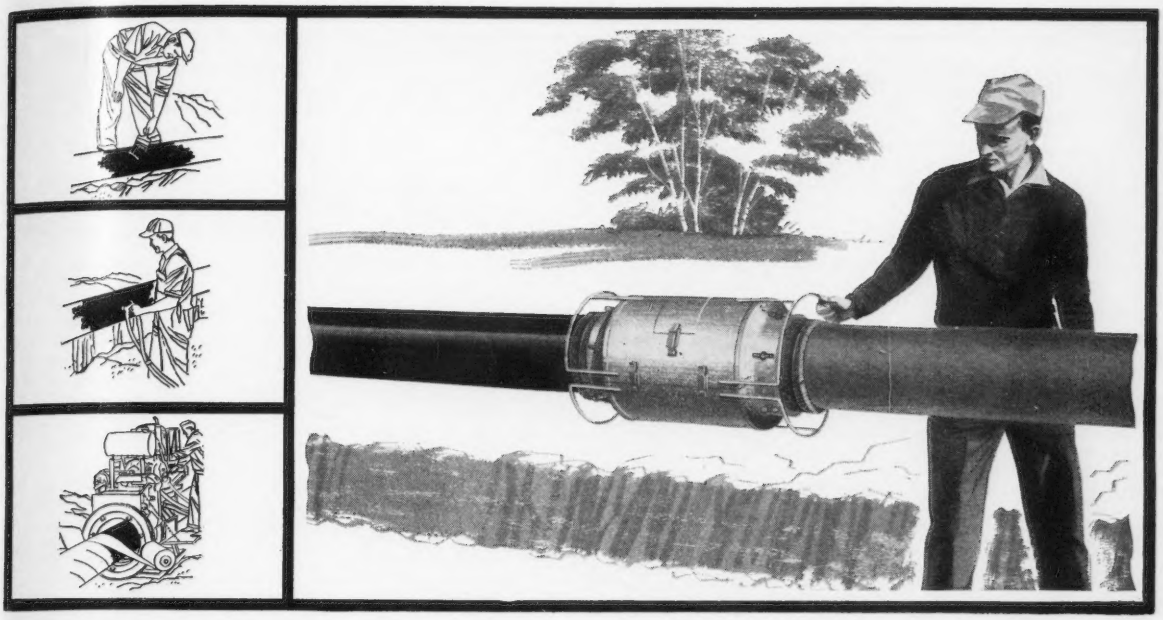
The method permits determination of the part of the surface area covered by the passivating layer formed through anodic polarization. Results of tests in various electrolytes are reported.

Authors postulate the repetitive oscillographic method in combination with the direct polarization method provides a means of testing among reactions occurring at a metal anode.

6.4.2, 5.11

Controlling Corrosion in Aluminum Fabrication. Part II. M. J. Pryor. Kaiser Aluminum & Chem. Corp. *Light Metal Age*, **12**, No. 1/2, 13-16, 33 (1955) Feb.

Accelerating influences that may appear in operating equipment of aluminum, but which do not usually arise



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during corrosion testing are as follows: simple entrapment of corrosive solution, crevice corrosion, concentration cell corrosion, bimetallic corrosion and corrosion fatigue. These influences are described and precautions are suggested. —INCO. 9636

6.4.2

Applied Finishes for Aluminium Alloy Die Castings. H. K. AND L. C. BARTON. *Machinery*, **84**, No. 2167, 1143-1148, 1153-1154 (1954) May 28.

Since the active nature of aluminum results in an almost instantaneous formation of an oxide film on any exposed surface, the plating of aluminum die castings is much more difficult than that of zinc alloy die castings. Acid dips in nitric and hydrofluoric acids are first required to remove surface contaminants and silicon smuts. The aluminum in the surface layer of the die castings is then replaced by zinc by a simple immersion process in a zincate solution. Once the casting has received an overall coating of zinc, any type of decorative plating can be applied normally. Other types of finishes and treatments discussed are anodizing, chemical conversion treatments, surface polishing, abrasive blasting, organic and stove finishes.—ZDA. 9793

6.4.2

Surface Treatments Improve Properties, Broaden Uses of Aluminium. Parts I, II. C. C. COHN. *Iron Age*, **174**, Nos. 25, 26, 111-114, 65-68 (1954) Dec. 16, Dec. 23.

Various surface finishes for aluminum. Bright finishes, chemical oxide coatings, coloring, preparation for plating and painting, etc. Cleaning aluminum prior to application of surface finish, soldering, welding and brazing: methods used are electrocleaning, organic solvents, etching, alkali and acid cleaning.—BNF. 9706

6.4.2, 2.2.2, 8.1.2

1) Examination of an (Aluminium) Sheet from the Roof of the Church of San Gioacchino in Rome. 2) Technique of Aluminium Roof Coverings (3rd edition). Istituto Sperimentale dei Metalli Leggeri Report No. 200, 350/2201, March 21, 1950, 7 pp.; Translation: Aluminium Laboratories Report No. B-TM-139-54. Istituto Sperimentale dei Metalli Leggeri, Note d'Officina No. 43; Alluminio, **23**, No. 2, 177-216 (1954).

1) Examination of aluminum sheet after 53 years' exposure (1896-1949). Chemical composition gave 98.65 percent aluminum, loss in U.T.S. was only 1.6 percent and maximum depth of pitting was 0.08mm. Sheet in excellent condition, attributed to the good ventilation inside the cupola.

2) Types of roof structures; dimensions of sections in corrugated-sheet and other sectional roofs; advantages of aluminum, techniques employed, relevant data, examples (including flashings, etc.)—BNF. 9693

6.4.2, 5.9.4, 5.4.5

The Protection of Aluminium and Alloys by Paint. Parts I, II. ANDRE GUILHAUDIS AND (MME) REGINE BOURBON. *Rev. Aluminium*, **31**, Nos. 206, 207, 7-10, 47-51 (1954) Jan., Feb.

Part I) Deals with preparation of the aluminum surface by degreasing, either with organic solvents or electrolytically (cathodic), followed by either mechanical scouring (sand blasting) or acid treatment. The various treatments are described in detail and their suitability for different classes of material is indicated. The advantages of anodic-oxidation processes, as against purely chemical processes, are pointed out, particularly those giving a porous surface to act as a key to the paint, but their high cost and limitation of size is against their general use.

Part II) Gives the results of exposure, tests, inland and marine, on test samples painted with various classes of undercoats and top coats, and with different preliminary surface treatments. In general it is shown that better results are obtained by acid treatment than by simple degreasing, and that zinc chromate and phosphate undercoats are better than synthetic enamels. For top coats the best results are given by oil paints, and it is shown that the nature of the undercoat has little influence on the life of the top coat. Tests on all classes of anti-fouling compounds are given, and it is shown that all these attack aluminum, and it therefore necessary to interpose an undercoating, preferably of the zinc chromate type. 4 references.—MA. 9296

6.4.2, 6.6.4, 3.6.6

Aluminum-Graphite Galvanic Couple in Light-Alloy Corrosion. (In Italian). A. PRATI. *Alluminio*, **23**, No. 6, 639-649 (1954) Dec.

Results of corrosion tests made on Raffinal alloy and short-circuited with graphite. Micrographs, photographs, tables, graphs, diagrams. 7 ref.—BTR. 9322

6.4.4, 1.6

Development of Magnesium-Lithium Structural Alloys: Final Report. P. D. FROST, V. S. EMLER, AND J. H. JACKSON. U. S. Bur. Aeronautics Navy Dept. Rep., ATI-123450, 79 pp., 1951; unclassified, 1954 (on micro-cards).

A study has been made of the mechanical and other properties of magnesium-lithium-base alloys. The magnesium alloys showing greatest promise for structural applications contained 1) lithium 9.5, aluminum 7, tin 1 percent and 2) lithium, 9, aluminum 5, zinc 8 percent. It was found that the latter alloy had properties at 200°F (95°C) superior to those of a number of others of slightly differing composition; manganese decreased the stability of both these alloys. The stresses required for a creep rate of 0.0001 percent/hr were 18,600 lb/in² for alloy 1) and 19,300 lb/in² for alloy (2). Short-time ageing treatments at 400°F (205°C), or water-quenching after hot rolling, produced improved properties in alloy (2); typical properties were: Y. S. 37,000 lb/in², U.T.S. 54,000 lb/in,² elongation 7 percent, Rockwell E hardness 97.5. Alloys melted under argon did not appear to have properties superior to those of flux-melted ones. Alloy (1) had a greater corrosion-rate in a marine atmosphere at the end of four months than at the end of two, but the rate had decreased after eight months; alloy (2) showed a continuous decrease in corrosion-rate. Variable stress-corrosion data for the alloys are reported. It was found that at high temperatures, i.e. during solution-treatment, lithium was lost from the surface of the alloys and a hexagonal magnesium-rich alloy was produced; the addition of 0.5 percent sulfur dioxide to the atmosphere minimized this loss of lithium.—MA. 9295

6.4.4, 3.6.6, 5.9.4

Contact Corrosion of Magnesium Alloys and Their Protection by Means of Metallic and Oxide Coatings. A. V. SHREIDER. *J. Applied Chem., USSR* (Zhurnal Prikladnoi Khimii), **27**, No. 7, 735-756 (1954) July.

Extensive investigation of contact corrosion between various magnesium alloys and great variety of steels (including stainless, high chromium, etc.), copper, nickel and aluminum alloys in 3 percent sodium chloride solution, tap water, and manufacturing plant atmosphere. Eight different means of protecting steel parts were evaluated. Thirteen protective film-forming processes on magnesium alloys are described and tested. Best results obtained with fluoride-chromate films (high corrosion resistance, dimensional stability and surface cleanliness), oiling of treated surfaces also investigated. Detailed experimental data are tabulated and charted. 10 tables, 12 figures, 16 references. Translation available: Assoc. Tech. Services, Box 271, East Orange, N. J.—ATS. 9349

6.4.4, 3.8.4

Burning Times of Magnesium Ribbons in Various Atmospheres. KENNETH P. COFFIN. Nat'l. Advisory Comm. Aeronaut. Tech. Note No. 3332, 37 pp., Dec., 1954.

The purpose of this investigation was to study the gross physical mechanism of the combustion of magnesium metal in order to learn whether a vapor phase of surface reaction is involved; further, to examine the effect of the composition of the oxidizing atmosphere, both as a matter of general interest and in the hope that such studies might be informative as to the details of the physical and/or chemical processes involved. Magnesium ribbon was burned in 17-100 percent oxygen mixtures with argon, nitrogen, helium, and argon-water vapor as diluents. Data are presented in terms of burning times for a strip of ribbon about 4.6 centimeters long; such data bear an approximately inverse relation to average burning rates. The experimental data are compared with average burning times calculated from hypotheses involving diffusion and heat transfer relations; the effects of moisture are less satisfactorily explained. The occurrence of vapor-phase combustion process is strongly indicated on the basis 1) the experimental observations and 2) the comparison between experimental and calculated burning times. Results are given.—ALL. 9415

6.5 Metals—Multiple or Combined

6.5, 1.6, 5.11

Metals Handbook, 1954 Supplement. Book, 1954, 184 pp. American Society for Metals, 7301 Euclid Avenue, Cleveland 3, Ohio.

This book is the first supplement to the 1948 edition of the Metals Handbook. It brings up to date those sections in the 1948 Handbook which have experienced the greatest advancement. The technical information was compiled by 22 author committees appointed by the society's Metal Handbook Committee.

Of likely interest to corrosion engineers are chapters concerning corrosion information on stainless steels, aluminum and aluminum alloys, copper and copper alloys and titanium and titanium alloys. Magnesium used for cathodic protection is mentioned. Corrosion resistance as a factor in the design of brazed joints is also dealt with.

An entire chapter is devoted to the selection of metal cleaning methods. The

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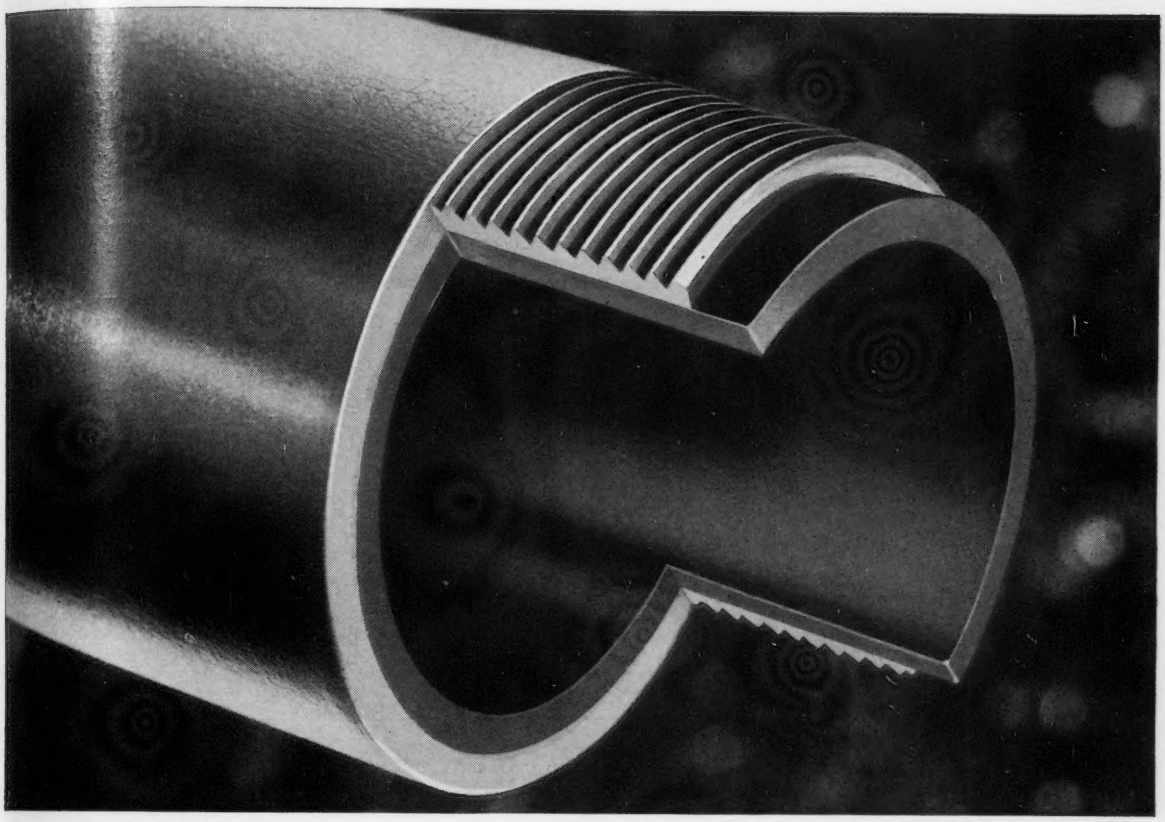

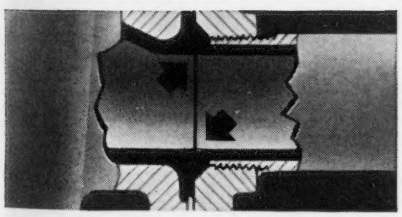

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book is divided into three parts: Metals and Applications; Design and Application; and Processing and Testing. There is an extensive subject index. 9355

6.6 Non-Metallic Materials

6.6.5

The Effect of Surface Active Substances on the Change in Structure of Concrete. V. A. TIKHONOV AND L. A. TIKHOMIROVA. *J. Applied Chem. USSR* (Zhurnal Prikladnoi Khimii), **27**, No. 10, 1067-1081 (1954) Oct.

Various types of cements and concretes were found to exhibit higher mechanical strength as a result of addition of such surfactants as sulfite-alcohol liquor, ammonium lignosulfonate, etc. Detailed X-ray and electron-microscope data are reported. 26 references. Translation available: Assoc. Tech. Services, Box 271, East Orange, N. J.—ATS. 9397

6.6.6, 4.7, 6.3.21

A Study of the Reaction of Thorium with Some Pure Refractory Compounds. G. R. PULLIAM AND E. S. FITZSIMMONS. Ames Lab. U. S. Atomic Energy Comm. Pubn., ISC-550, Dec. 10, 1954, 16 pp.

The effect of thorium metal on various refractory compounds was studied. The penetration of molten thorium into the ceramic was studied by microscopic examination of polished specimens. The reaction of powder mixtures heated to temperatures ranging from 1000 to 1800°C was studied by x-ray diffraction patterns. Stabilized zirconium dioxide proved to be the least reactive with massive thorium of those compounds studied. (auth).—NSA. 9323

6.6.6, 5.4.2

Ceramics for High-Temperature Applications. ALEXANDER PECHMAN. *Aircraft Eng.*, **26**, No. 303, 157-160 (1954) May.

After referring to some of the general features of ceramics, Pechman mentions some of the properties of alumina, magnesia, zirconia, beryllia, and thoria. Developments of and from U. S. National Bureau of Standards ceramic coatings A417 and A418 and application of ceramic coatings by Ryan Aeronautical Co. are described. Parts of exhaust systems of piston engines are ceramic-coated for protection against oxidation, carbon absorption, and corrosion attack, and inner combusion chambers of aeroturbines in ceramic-coated Type 321 stainless steel have been used in place of nickel-rich alloy. Present developments in the field of cermet bodies and cermet coatings, and also in vapor-deposition techniques of coating are mentioned.—MA. 9325

6.6.6, 8.5.2, 3.8.2

Galvanic Potentials in Silicate Melts. *Glass Industry*, **35**, No. 8, 433-436, 454 (1954) Aug.

Review of literature on corrosion of refractories by glass melts. Electrochemical methods of investigation emphasized. Bibliography.—BL. 9628

6.7 Duplex Materials

6.7.2

Progress Report on Cermets. (In German.) F. W. GLASER. *Planseeber. Pulvermet.*, **2**, No. 2, 59-70 (1954) Nov.

A survey (no references) of the present development of materials for service at 870-1150°C. Physical properties; existing cermet compositions; titanium carbide base cermets (at present the most widely developed and used); borides of zirconium and chromium; and nickel aluminide. Creep (at 980°C), and impact resistance of several materials.—BNF. 9678

6.7.2, 6.6.6, 6.6.4

Research and Development in the Field of Carbides, Nitrides, Silicides, and Borides for Aircraft Propulsion: A Status Report. LLOYD D. RICHARDSON, SR. *J. Electrochem. Soc.*, **101**, No. 9, 222c-224c (1954).

Ceramics and metal carbides that have been tested are described, and the reasons for concentrating attention on titanium carbide are given. Titanium carbide with free carbon <0.02 Percent can now be produced, but other contaminants, e.g. oxygen, nitrogen, iron, and chlorine, introduced during milling may also be very detrimental. The properties of the bonded carbide have been improved by alloying the nickel or cobalt binder with molybdenum, aluminum, and chromium, but the impact strength is still very low. It is expected that improved fabrication methods, e.g. extrusion, will improve the mechanical properties. Other intermetallic materials that may have useful properties are borides, nitrides, and aluminides, and specialized applications of these are described. For extremely high-temperature applications, e.g. rockets and ram jets, graphite is being considered.—MA. 9319

7. EQUIPMENT

7.1 Engines, Bearings and Turbines

7.1, 4.2.3

Problems Raised by the Combustion of Heavy Fuels in Gas Turbines. (In French). PETER SULZER. *Revue universelle mines*, **10**, Ser. 9, No. 12, 715-724 (1954) Dec.

Deposit formation; corrosion of steels under the effect of ashes containing vanadium; remedies. Photographs, diagrams, graph, table.—BTR. 9382

7.1, 5.6.3

Protection of Aircraft Piston Engines Against Corrosion During Storage. D. GOLOTHAN. *Shell Aviation News*, No. 195, 19-22 (1954) Sept.

Causes of corrosion, methods of prevention, external (protective oils, fluids, vapor phase inhibitors) and internal (static, dynamic inhibition, flyaway oils) protection, oil specifications and methods of engine testing and note on Thornton Petter engine corrosion test are given.—INCO. 9688

7.1, 8.9.4, 4.2.3

Coal-Burning Gas Turbine. *Engineer*, **198**, 370-372 (1954) Sept. 10.

Review of current performance of test installation of Locomotive Development Committee of Bituminous Coal Research, Inc., New York, of the Allis-Chalmers 4250 h.p. gas turbine power plant, designed for locomotives and which has now operated for more than 2000 hours with direct-fired coal burning. Characteristics of coal used, coal preparation and coal pump are given. First 178 hours' operation gave no damage to blading due to erosion; ash particles less than 20 microns. Serious erosion when coarser ash reached turbine followed development of leak in ash separator. Improved designs of ash separators and performance of these are given. Relatively small diameter of separator body now used permits application of more freely available Incoloy instead of Inconel X used originally. ¾-in. thick Incoloy was used for first 7 in. of each separator tube, remainder being of Type 347. Research was sponsored at Armour to establish new methods of detecting whether erosive ash was being admitted to turbine: two methods developed were based a) on utilizing change on electrical resistance of sample exposed to erosion and b) on use of irradiated S-590, containing Co^{60}. Methods and results are given. Compositions of materials are tabulated. —INCO. 9293

7.4 Heat Exchangers

7.4.2, 6.3.6

Corrosion of Copper and Copper Alloy Tubes. D. B. THOMPSON. Paper, 1954 Ann. Mtg., Australian Inst. Metals, June 1-3, 1954, p. 23-31; *Australasian Engr.*, 1954, 48-56; disc., 56-59, Oct.

Discusses corrosion of condenser and heat-exchanger tubes in light of modern theory including oxygen ionization, cupricion corrosion, effects of ashes, carbon deposits, chlorides, sulfates, sulfides, internal stress, and high rate of water flow, dezincification, film formation, impingement corrosion, stress corrosion, corrosion fatigue, bacterial corrosion, and season cracking. Diagrams, micrographs, photographs, 21 references.—INCO. 9395

7.4.2, 6.4.2, 4.6.4

Heat Exchanger Tubes. Pamphlet, 1954, 24 pp. Aluminum Co. of America, Alcoa Building, Pittsburgh 19, Penn.

Types of aluminum alloy heat exchanger tubes; effect of cooling waters; applications in the petroleum and chemical industries; heat transfer and fluid flow characteristics; specifications and data for Alcoa aluminum alloy heat exchanger tubes.—BNF. 9342

7.6 Unit Process Equipment

7.6.4

Problems Related to Corrosion of Automatic Gas-Fired Galvanized Steel Hot Water Storage Tanks. R. C. WEAST. Memorandum prepared for Am. Gas Assoc. Tech. Advisory Group for Domestic Gas Water Heating Research, June, 1951. Am. Gas Assoc., Research Report No. 1151B, 1954, 50-52.

Galvanic corrosion, most severe in waters containing large amounts of dissolved salts, can be reduced by treatment of water with sufficiently high concentrations of silicates or soluble polyphosphates or stopped by proper application of cathodic protection. Special type of galvanic corrosion results from fact that water relatively high in free or uncombined carbon dioxide is corrosive to copper and, after flowing through brass or copper pipe, may contain dissolved copper sufficient to cause increased corrosion rate of galvanized tank. Reversal of potential between zinc and iron occurs in certain waters when they are heated to 150°F or higher. Since copper and brass are electronegative to steel, accelerated corrosion will occur whenever either is connected directly to tank. Bacterial corrosion, temperature, water composition, and quantity of daily flow of dissolved oxygen-containing water are other factors influencing corrosion in hot water storage tanks.—INCO. 9487

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7.6.4, 3.5.8

Investigation of Cracking in Stainless Steel Auxiliary Boilers for AM 421 Class Mine Sweepers. W. LEE WILLIAMS. Naval Engineering Experiment Station, Annapolis, EES-040038F (3), April 5, 1954, 30 pp.

Parts of three low-pressure stainless steel boilers were examined after having been steamed approximately 1,000 hours. All of the boilers had developed stress-corrosion cracks. The cracks originated from the waterside in crevices near welds. The problem was discussed in relation to stress-corrosion data obtained in another Station investigation. (auth). —NSA. 9458

7.6.4, 3.5.8, 3.7.3

Investigation of Cracking in a Silicon Bronze Auxiliary Boiler for AM 421 Class Mine Sweepers. W. LEE WILLIAMS. Naval Engineering Experiment Station, Annapolis, EES-040038F (8), Oct. 15, 1954, 24 pp.

This report is the fourth in a series dealing with the problem of cracking in auxiliary boilers for nonmagnetic mine sweepers. It covers a destructive examination of a Cyclotherm type boiler, made of silicon bronze except for copper tubes. This boiler had leaked after 2,042 hours of operation. The rolled tube joints were in good condition, and the few joint leaks were attributed to relaxation of the copper tubes. The leaks at the fire tube-header welds were caused by weld cracking from the fireside, and progression of the cracks from thermal stresses during operation. The shell leaks were caused by waterside stress-corrosion near welds. The boiler had not been stress relieved after fabrication. (auth).—NSA. 9475

7.6.4, 3.6.2, 3.7.3, 3.5.8

Investigation of Cracking in Stainless Steel Auxiliary Boilers for AM 421 Class Mine Sweepers. W. LEE WILLIAMS. Naval Engineering Experiment Station, Annapolis, EES-040038F (6), Aug. 6, 1954, 32 pp.

This is the second report in a series dealing with the problem of cracking in stainless steel auxiliary boilers for nonmagnetic mine sweepers. Inspection of several boilers and of laboratory corrosion specimens tested in high temperature water are discussed. The work confirms previous observations regarding the susceptibility of stainless steel to stress-corrosion cracking in boiler water environments of practical interest. The most critical zones are those in which waterside crevices exist near welded joints. The problem has not yet been solved, but steps are being taken along three lines: redesign of joints to eliminate crevices; development of special boiler water treatments; and, the use of nonmagnetic constructional materials other than stainless steel. (auth).—NSA. 9477

7.6.8, 5.8.2

Organic Corrosion Inhibitors for Distillation Units. J. TOURRET. Paper, Assoc. Francaise Tech. Petr., Equipment and Design Sect. Meet., May 13, 1954; Bull. Assoc. Francaise Techniciens Petrole, No. 106, 317-321 (1954) July 31.

The use of organic inhibitors to combat corrosion in the upper sections of fractionating towers is reviewed briefly. A preferred inhibitor consists of a polar group attached to a hydrocarbon-soluble radical and forms a monomolecular film on the metal. The material, in concentrated form, is injected continuously into the gasoline reflux line near the point of withdrawal from the tower. 9396

7.7 Electrical, Telephone and Radio

7.7

Influence of Electrical Current on Contact Between Metals. F. P. BOWDEN AND J. B. P. WILLIAMSON. *Research Correspondence* (Supplement to *Research*), **7,** No. 10, S53-S55 (1954) Oct.

Short duration current pulses of sufficient intensity to cause softening at asperities were applied and the effect on the construction resistance, mechanical strength and microstructure determined, using gold blocks to avoid oxide films.—BNF. 9500

7.7, 6.4.2

Television Aerials and Frequency Modulation. (In Italian). *Alluminio,* **23,** No. 3, 297-327 (1954) May.

The article provides builders of TV light-metal aerials with the necessary information about aluminum alloys, their important mechanical and electrical characteristics and their performance in outside use. Standard types of aerials are described. The composition of alloys used for TV aerials is outlined in a table. Mechanical characteristics of light alloy pipes, compared in a table, help the constructor to choose the material suitable for his special purpose. The electrical characteristics of TV aerials depend on their geometric dimensions. For economical aerials Aluman and Peraluman 15, and Anticorodal 63 are most widely used. For increased mechanical resistance without losing corrosion resistance in salt or industrial atmospheres, Anticorodal 11 is recommended. A table, indicating the physical qualities, shows that the elastic modulus for all these alloys remains about 7,000 kg/sq mm and that the electric resistance is sufficiently low. Therefore aluminum alloys present an excellent material for high radio-frequency aerial construction. Anodizing is not advisable because the anodic layer influences the surface resistance. Directions are given for bending, welding, brazing, etc. The article is followed by a series of tables giving constructional and electro-technical details for different types of short-wave (1 to 5m) TV aerials.—ALL. 9309

7.7, 6.4.2, 2.2.2

Service Experience of the Effect of Corrosion on Steel-Cored Aluminium Overhead-Line Conductors. J. S. FORREST AND J. M. WARD. Inst. Elect. Eng. Preprint S1611, 1954, 13 pp.; *Proc. Inst. Elec. Engrs.,* 101, Pt. 2 (*Power Eng.*), No. 81, 271-290 (1954) June; see also: *Engineer,* **197,** No. 5114, 170-171 (1954) Jan. 29; *Engineering,* **177,** No. 4593, 183 (1954) Feb. 5.

An account is given of experimental work done during the past 20 years to determine the effects of atmospheric corrosion on the steel-cored aluminum overhead-conductors of the Grid system. Details are given of the methods employed for assessing corrosion, these consisting of mechanical techniques, electrical methods, determination of the weight loss, and measurements of the depth of pitting and the reduction in cross-section. The results of the investigations cover the periods 1934-49 and 1949 to date. The results for the latter period are based on a comprehensive survey of the condition of the conductors throughout the country, and cover a reasonably long period of service. The average rate of deterioration, based on the reduction in mechanical strength, is calculated as being ~0.5 percent/year. The average service life of the conductor is 25-30 years. The types of corrosion experienced are discussed in some detail, examples being given of the very serious corrosive attack experienced in some industrial areas in which there was very little attack of the steel core. Coastal area corrosion took the form of bulges or swellings between the steel core and the aluminum strands. The mechanism of conductor corrosion of the various types is discussed and an account given of the factors that appear to cause variations in the corrosion of conductors of equal age. It is possible that the electrostatic effect of the voltage on the conductors causes the attraction of solid particles, and thus accelerates the corrosion of the outer conductors. The desirable properties of protective materials are listed and the results of tests on protective greases given. Some information is presented on the probable value of homogeneous aluminum-alloy conductors, but there is some doubt about the corrosion-resistance of the metal.—MA. 9450

7.7, 7.2

Corrosion Control of Underground Power Cables in New York. F. E. KULMAN. Paper before Am. Inst. Elec. Engrs. Winter Gen. Mtg., New York, Jan., 1954. *Trans. Am. Inst. Elec. Engrs.* (Power Apparatus & Systems), **73,** Pt. 3, No. 13, 745-760 (1954) Aug.; *Elec. Eng.,* **73,** No. 5, 450 (1954) May.

Discusses methods of determining corrosive areas, rate of corrosion, etc., by electrolysis surveys and tests. Cable sheaths and pipes are protected by cathodic protection, and coatings such as neoprene on lead cable sheaths, petroleum grease during installation and asphalt mastic coating on steel pipes.—INCO. 9469

7.8 Wires and Cables—non-electrical

7.8, 2.2.2

Report of (A.S.T.M.) Sub-Committee XV on Atmosphere Exposure Tests of Wire and Wire Products (Covering 1953 Inspections). FRED M. REINHART. Am. Soc. Testing Materials Preprint No. 3, 18-22 (1954).

Tables summarizing the appearance of wire, chain-link fencing, etc., at eleven locations after seventeen years' exposure are presented.—MA. 9490

7.8, 5.3.4

Composite Wires by Electroplating. E. C. SLICK. Paper before Wire Assoc. Ann. Conv., Detroit, November 9, 1954. *Wire & Wire Products,* **29,** No. 11, 1324-1326, 1362-1368 (1954) Nov.

Electroplated composite materials have many advantages including uniform coating, well bonded coating, combined properties of several metals, corrosion resistance, good workability and replacement for scarce materials. Discussion of continuous electroplating of wire includes equipment, surface preparation, plating process, nickel bath, base material, and coating prior to reduction. Drawing lubricants and dies are discussed. Heavy sections of nickel on steel may be drawn with dry soaps. Intermediate sizes (.04-.005 in) are reduced using fluid type compounds. Nickel-plated steel is reduced 30 percent each pass while nickel on copper gives best results with 15 percent reductions. Nickel on low carbon steel is heat treated 1350-1400°F to in-

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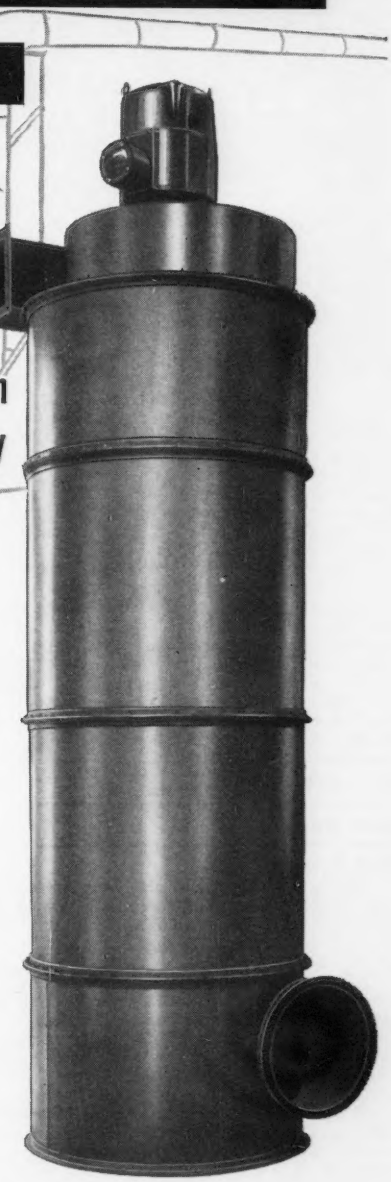

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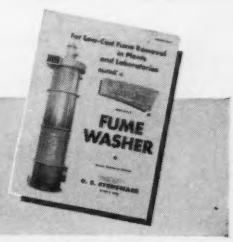

sure ductility of nickel. Graph for estimating nickel thickness on steel base wire is presented. 8 references.—INCO. 9377

7.10 Other

7.10, 6.3.6, 5.3.2

Further Tests on the Stability of Analytical Weights in Chemical Laboratories. P. H. Bigg and F. H. Burch. *Brit. J. Appl. Physics*, **5**, No. 11, 382-386 (1954) Nov.

Continuation of previous work [**ibid., 2**, 126 (1951)] on the stability of the mass of analytical weights exposed to the atmosphere of chemical laboratories. Work has been extended to brass weights electroplated with the normal thicknesses of 13 and 25μ of 65:35 tin-nickel alloy. The appearance of the 25-μ coating was the best, and was comparable with that of weights of highly polished stainless steel except under the severest conditions. All the tin-nickel alloy-coated weights showed about the same mass-stability as good-quality commercial weights of austenitic stainless steels and rhodium-plated brass weights. The tin-nickel alloy plating does not possess any undesirable magnetic properties. In high-corrosive atmospheres, a non-magnetic nickel-chromium coating is a little less resistant than the others. Of the small sheet-metal weights tested, those made of austenitic stainless steel were definitely the best, followed, in order of merit, by weights of zirconium, tantalum, aluminum, and titanium. It is pointed out that in weights having a tin-nickel coating of nominal thickness 25μ, the actual thickness of coating diminished from ~23μ at the edge to 7μ at the center.—MA. 9357

8. INDUSTRIES

8.3 Group 3

8.3.1, 3.7.3, 6.2.3, 6.2.4

Effects of Methods of Manufacture and Steel Specifications on the Service of Disks. I. F. Reed and W. F. McCreery. U. S. Dept. Agriculture. *Agr. Eng.*, **35**, No. 2, 91-94, 97 (1954) Feb.

Effects of hardness, method of rolling steel, type of edge, types of steel (SAE 1080 and 6160 were used), method of forming notches in disks, and type of mounting are discussed. Laboratory wear tests of SAE 6160 and SAE 1080 steels show that the weight loss for both types of steels tended to decrease with hardness. Study indicates that manufacturers of disks should, if possible, increase the carbon content of their carbon steel disks to SAE 1085 or SAE 1090 and heat-treat to obtain hardness in the range of 42-44 on the Rockwell C scale. Cross rolling the steel definitely increased impact and fatigue resistance. Illustrations. 4 references.—INCO. 9465

8.4 Group 4

8.4.3

Corrosion in the Petroleum Industry. Parts I, II, III. F. H. Garner and A. R. Hale. *Petroleum* (London); **17**; Nos. 11, 12; 407-410, 440-442 (1954); *ibid.*, **18**, No. 1, 12-14 (1955).

Corrosion problems in the two main types of refinery processes are surveyed: those arising in the distillation and cracking of petroleum, and those resulting from the use of chemicals either for the refining of petroleum products or for the synthesis of hydrocarbons. In distillation and cracking operations both low-temperature electrolytic corrosion and high-temperature corrosion are encountered. In Part I the materials used for pipe-still heaters, fractionators, reactors, and condensing equipment are described and in Part II those in catalytic crackers. The requirements of plant in which sulfuric acid and phosphoric acid are used for treating petroleum products are then considered. In Part III equipment for handling hydrofluoric acid and aluminum chloride in isomerization processes, and solvent refining reagents including furfural, phenol, chlorinated solvents, and sulfur dioxide, is described and the corrosion-resistance of storage equipment discussed. —MA. 9677

8.4.3

Acidizing. J. G. Staudt. Dowell, Inc. *Petroleum Engr.*, **1954**, B-55, July.

Inhibited acid has been used successfully for 22 years as a valuable tool in oil and gas well treating. This article presents a history of this process from its early beginnings up to the present highly developed, new and improved techniques. —VISCO. 9378

8.4.3, 4.4.7

Something Has Been Added: Thirty Years' Progress in the Improvement of Fuels and Lubricants by the Use of Additives. L. C. Beard, Jr. *ASTM* Bull., No. 198, 51-56 (1954).

Refers to anti-rust additives and also to the magnitude of corrosion problems in the oil industry during production, refining, storage, and distribution.—MA. 9362

8.4.3, 4.4.3, 4.4.8, 5.8.2

Corrosion by and Deterioration of Glycol and Glycol-Amine Solutions. W. G. Lloyd and F. C. Taylor, Jr. Paper before Am. Chem. Soc., Div. of Petrol. Chem., 124th Mtg. Chicago. *Ind. and Eng. Chem.*, **46**, No. 11, 2407-2416 (1954) Nov.

Experiments clarifying chemical factors affecting vapor-condensate corrosion of steel equipment by aqueous diethylene glycol and glycol and glycol-amine solutions in industrial processes in which they are used as dehumidifying agents. Corrosion is determined by means of a series of reflux tests. Vapor-condensate corrosion rate over diethylene glycol-water solutions is dependent on pH (glycol solutions with pH's in the vicinity of 8 appear to be uniformly noncorrosive), and in the presence of oxygen and the absence of buffer or antioxidant additives, the glycol is subject to autoxidation at elevated temperatures to produce acids. Mineral buffers such as potassium mono hydrogen orthophosphate and amine additives such as monoethanolamine will inhibit corrosion. The highest rates of corrosive attack by glycol-amine gas-treating solutions are observed in atmospheres of mixed carbon dioxide, hydrogen sulfide, and oxygen. The corrosion of aluminum by glycol-amine solutions was tested since aluminum alloys have been substituted for steel in certain portions of heat exchangers and stripping stills by some manufacturers. The effects of a number of solvent additives on the corrosion of aluminum by monoethanolamine solutions are tabulated. The least polar additives (tetraethylene glycol, dimethyl ether and dioxane) afford the lowest rates of corrosion. Solution deterioration and solution viscosity are discussed. Graphs, tables, 30 references.—INCO. 9539

8.4.5

Liquid Metal Fuel Reactor (LMFR) Processing Loops. Part 1. Design, Construction, and Corrosion Data. C. J. Raseman and J. Weisman, compilers. Brookhaven National Lab. U. S. Atomic Energy Comm. Pubn., BNL-322, June, 1954, 28 pp.

Experiments with three liquid-metal circulation loops are described. Two of the loops were used for isothermal studies on uranium-bismuth corrosion of stainless steel container material, together with independent evaluations of various fuel handling and instrumentation procedures. The third loop was used to determine mass transfer effects of uranium-bismuth on stainless steel under nonisothermal conditions. The design of the three loops is described in detail, and several examples of corrosion and plugging are discussed. The performance characteristics of associated loop instrumentation are given. (auth).—NSA. 9321

8.5 Group 5

8.5.3

Deposits in Green Liquor and Causticizing Systems—A Contribution of the West Coast Alkaline Pulping Sub-Committee. W. W. Brown. Paper before Can. Pulp & Paper Assoc., Tech. Sec., Victoria, B. C., June 14-17, 1954. *Pulp Paper Can.*, **55**, No. 8, 134-136 (1954) July.

Nature and magnitude, analysis, possible causes of and corrective measures for deposits in green liquor systems. Lines between classifier and first causticizer, and between white liquor clarifier underflow and mud washer, appear to be focal points of liming. Use of stainless steel and/or concrete proved to be an effective countermeasure against corrosion.—INCO. 9287

8.8 Group 8

8.8.1

Corrosion in Chemical Plant. T. K. Ross. *Chem. Age*, **71**, 655-659 (1954) Sept. 25.

Attack by acid solutions; film growth. Electric potential of metal surfaces.—BTR. 9318

8.9 Group 9

8.9.5

A Shipbuilder Looks at Corrosion. P. Ffield. Bethlehem Shipbuilding Co. Paper before NACE, Greater Boston Sect.; *Mariner*, **1**; Nos. 10, 11, 12; 17-19; 44, 48, 56-58; 24-28 (1954) Oct., Nov., Dec.; also Paper, Soc. NAME, Northern California Section; *J. Brit. Shipbuilding Res. Assoc.*, **9**, No. 5, 296-297 (1954).

The author considers marine corrosion in three sections. First dealing with corrosion rates, he considers manufacturing practice, composition of shipbuilding steel and its method of working, water velocity, and the corrosive and protective effects of galvanic currents. Secondly he deals with cathodic protection in more detail and suggests how the hull may be considered as a large anode for the protection of the propeller. The relation of underwater paints in relation to galvanic effects is discussed. It is essential to insulate the anti-fouling paint from the hull by a coat of anti-corrosive paint. In the third section the applications of corrosion engineering to shipbuilding problems is the main topic. —RPI. 9443

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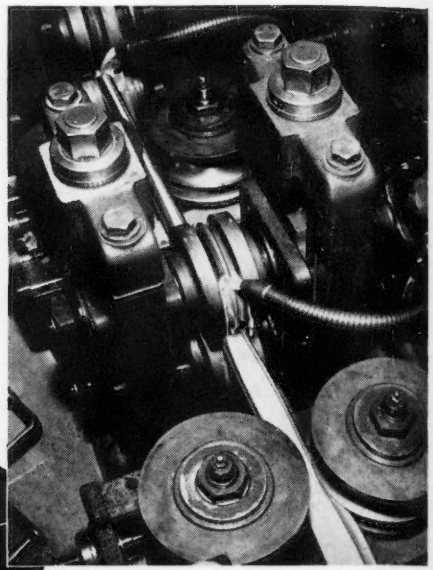

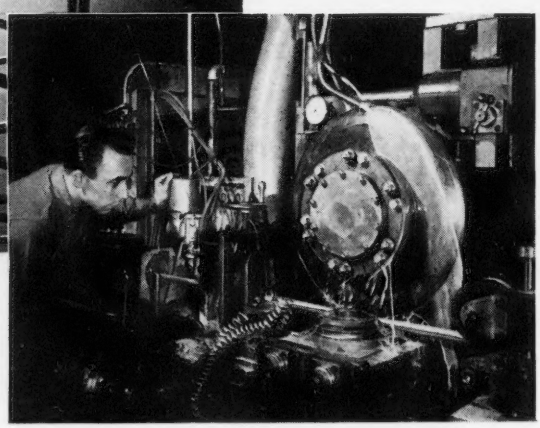

upper right: Galvanized sheet passes in continuous ribbon through forming mill.

lower right: Excess weld metal spirals off formed tubing after seam is butt-welded. Nodulizing gun under operator's left hand then applies zinc coat over seam weld, following which tubing is cooled and sheared to desired length. Photos courtesy *Welded Tube Company of America, Phila., Pa.*

Here is another application of zinc-coated steel made possible by the continuous galvanizing process. This method not only bonds the zinc much more tightly than conventional hot-dipping, but makes the zinc-coated steel available in long coils from which the tubing is formed. Even the welded and recoated seam is so smooth that only close inspection will reveal it.

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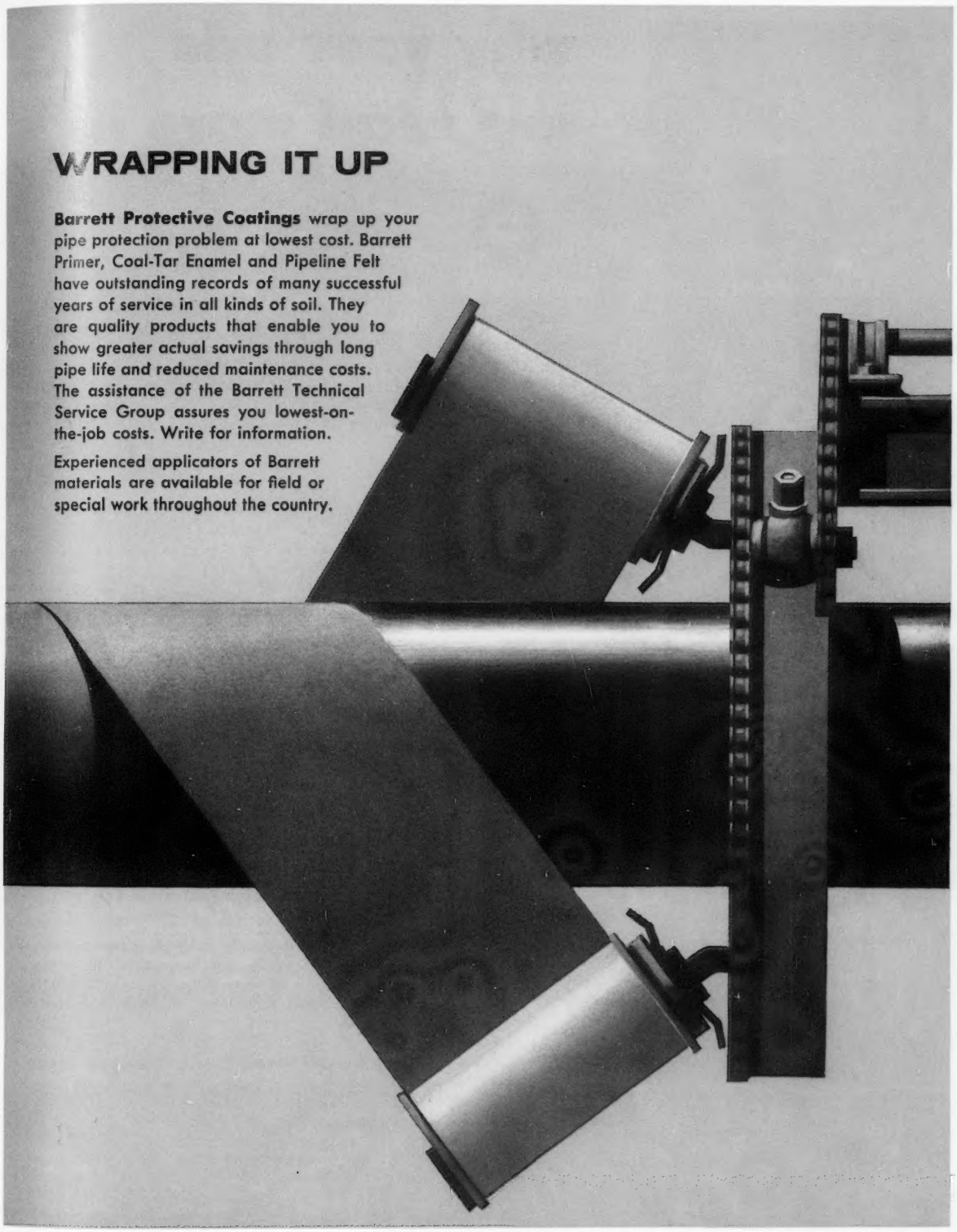

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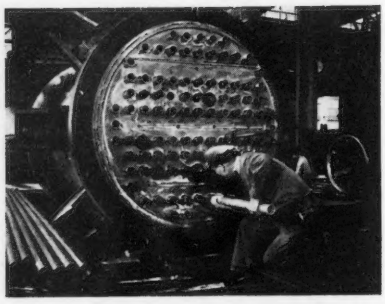

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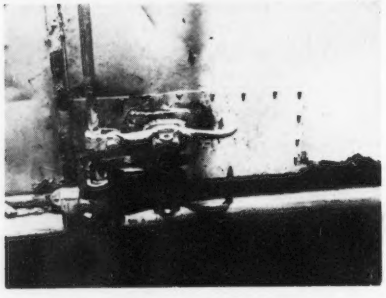

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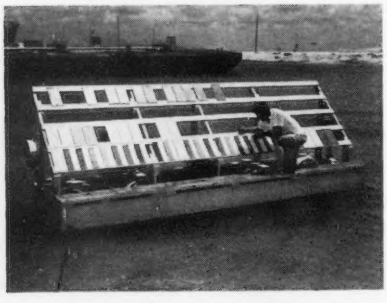

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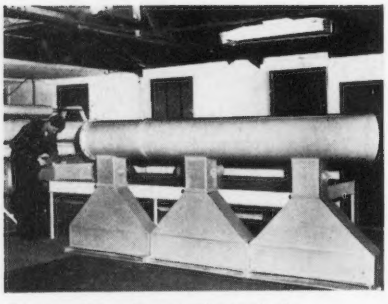

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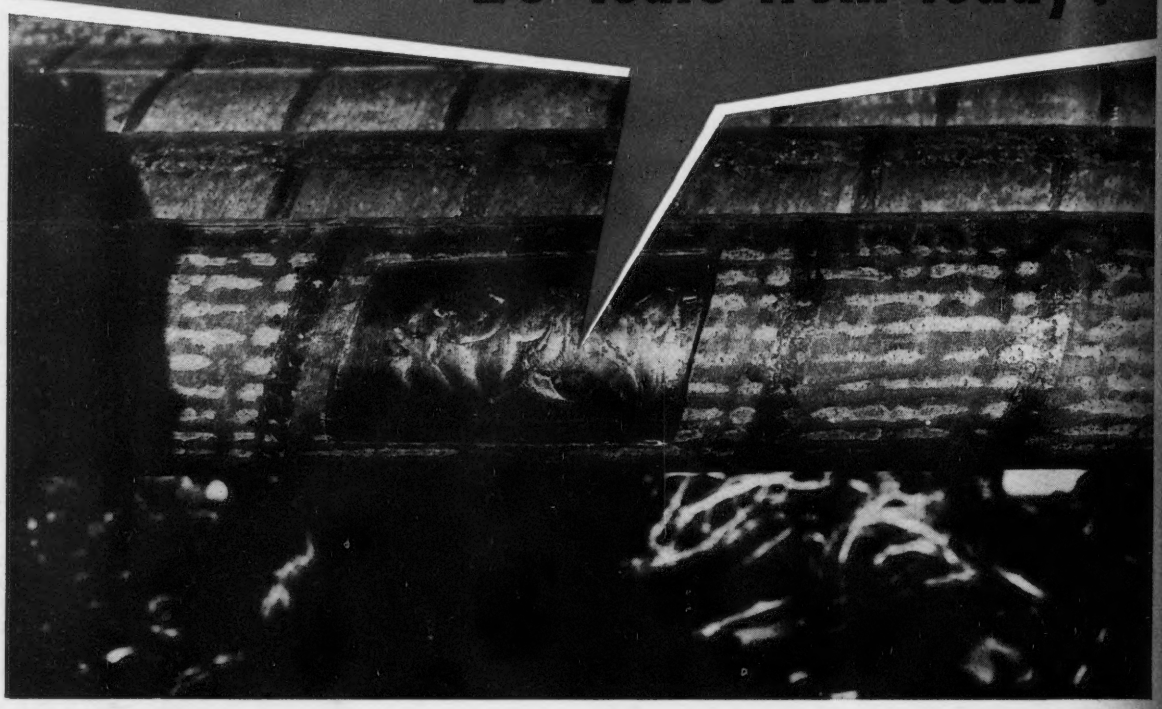

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